USAARL Report NO. 95-34

Utilization of Visual Ports in U.S Army Rotary-wing Aircraft

By

Rebecca H. Ivey
Clarence E. Rash
Richard R. Levine
Sean L. Wentworth
Everette McGowin III

Aircrew Health and Performance Division

August 1995

U.S. Army Aeromedical Research Laboratory
Fort Rucker, Alabama 36362-0577

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION U.S. Army Aeromedical Research Laboratory 6b. OFFICE SYMBOL (If applicable) MCMR-UAS-VS	7a. NAME OF MONITORING ORGANIZATION U.S. Army Medical Research and Materiel Command
6c. ADDRESS (City, State, and ZIP Code) P.O. Box 620577 Fort Rucker, AL 36362-0577	7b. ADDRESS (City, State, and ZIP Code) Fort Detrick Frederick, MD 27102-5012
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
0602787A	3M162 787A879	PE	164

11. TITLE (Include Security Classification)

(U) Utilization of Visual Ports in U.S. Army Rotary-Wing Aircraft

12. PERSONAL AUTHOR(S)
Rebecca H. Ivey, Clarence E. Rash, Richard R. Levine, Sean L. Wentworth, Everette McGowin III

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM _____ TO _____		

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Windscreen, transparency, utilization
13	06		
14	04		

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report documents the location and extent of visual ports (windows) in U.S. Army rotary-wing aircraft and assesses utilization and associated problems. The study was conducted in three parts: First, the visual ports of each aircraft type were documented through visual plots and photography. Second, questionnaire data for 334 aviators and crewmen addressing the use of and problems with each visual port were collected and analyzed. Third, a search of the U.S. Army Safety Center accident database was conducted to identify the frequency of accidents in which impaired vision was a possible factor.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION	
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL Chief, Science Support Center	22b. TELEPHONE (Include Area Code) (334) 255-6907	22c. OFFICE SYMBOL MCMR-UAX-SS

DD Form 1473, JUN 86 *Previous editions are obsolete.* SECURITY CLASSIFICATION OF THIS PAGE

Acknowledgments

The authors wish to thank Mr. Larry Thomas for his assistance in performing the photographic documentation for this investigation and Mr. Larry Woodrum and CPT Charles Dirks for their assistance in obtaining access to the aircraft.

Mr. Frank Bick of U.S. Army Troop Command (ATCOM), St. Louis, Mo., is thanked for his assistance in obtaining visual field plots.

A special thanks is extended to the aviators and crewmen at the various U.S. Army airfields who assisted in the distribution, completion, and collection of the questionnaires.

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Introduction

An investigation of visual ports (windscreens or windows) in rotary-wing aircraft of the U.S. Army was conducted. The objectives of the investigation were to document the location and extent of the visual ports and to assess utilization of these ports and associated problems for aviator and aircrew flight tasks. The investigation encompassed the eight currently fielded aircraft designs. These were the AH-1S/F Cobra, AH-64 Apache, CH-47D Chinook, OH-6 Cayuse, OH-58A/C/D Kiowa, TH-67 Creek, UH-1H/V Iroquois, and UH-60 Black Hawk. See Figures 1-10. [Note: The OH-58A and D models have the same windscreens and windows. The OH-58D model has instrumentation in the rear of the aircraft which blocks the rear doors. The OH-58C model exists with either curved or flat windscreens.]

The investigation was conducted in three parts. First, the visual ports in each aircraft were documented through visual plots and photography. Second, questionnaires addressing the utilization of each visual port were developed and administered to 344 aviators and aircrew . [Note: Since the TH-67 is a training aircraft and is not fielded by the U.S. Army, questionnaire data were not collected for this aircraft.] Third, a search of the U.S. Army Safety Center accident database was conducted to identify the frequency of the incidence of accidents for U.S. Army rotary-wing aircraft in which impaired external vision was a possible factor.

It is envisioned these data will serve as a reference source for accident investigation and future aircraft design.

External vision rationale and requirements

Flying presents a number of visually demanding tasks for pilots and crewmen. These include navigation, terrain avoidance, landing, collision avoidance, weapon delivery, etc. While futuristic aircraft designs may explore the concept of a totally enclosed cockpit, current rotary-wing aircraft designs are such that aviators depend heavily upon adequate external vision through windscreens and windows. This is particularly true in nap-of-the-earth (NOE) and contour flight modes where distances to potential obstacles are as short as a few feet. The size and placement of visual openings are critical to safe operation and, accordingly, to mission success. The requirements for external vision and for the needed visual ports are a function of the cockpit seating arrangement (e.g., single, tandem, or side-by-side) and the type of aircraft as defined by mission (e.g., attack, utility, trainer, etc.). U.S. Army rotary wing aircraft use either tandem or side-by-side seating arrangements. To date only attack aircraft (AH-1 Cobra and AH-64 Apache) use tandem seating with the pilot in the rear seat.

Tandem and side-by-side seating arrangements each have both advantages and disadvantages. For tandem seating, the major advantage is that both aircrew men have improved visual fields to both sides. The major disadvantage is the highly restricted over-the-nose vision

Figure 1. The AH-1S/F Cobra.

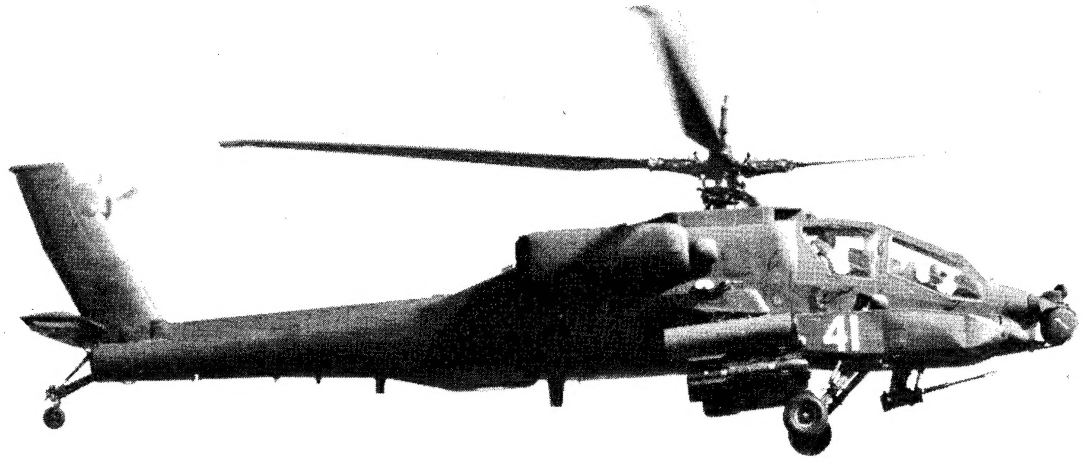


Figure 2. The AH-64 Apache.

Figure 3. The CH-47D Chinook.

Figure 4. The OH-6 Cayuse.

Figure 5. The OH-58A Kiowa.

Figure 6. The OH-58C Kiowa (flat panel).

Figure 7. The OH-58D Kiowa.

Figure 8. The TH-67 Creek.

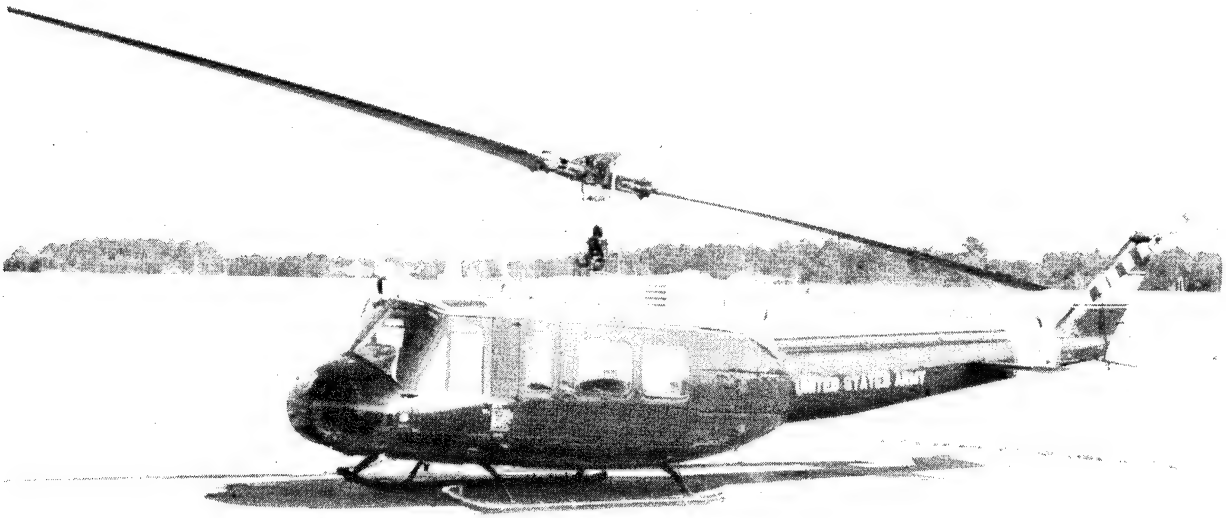


Figure 9. The UH-1H Iroquois.

Figure 10. The UH-60A Black Hawk.

for the pilot. Conversely, for side-by-side seating, the major advantage is the improved over-the-nose vision. The major disadvantage is the reduced vision for the opposite side.

The rationale and requirements for external vision are defined in Military Standard MIL-STD-850B, "Aircrew station vision requirements for military aircraft," Military Standard MIL-STD-1776A(USAF), "Aircrew station and passenger accommodations," and Military Specification MIL-W-81752A(AS), "Windscreen systems, fixed wing aircraft, general specification for." MIL-STD-850B is the primary document. Note: There are no Military Specifications specifically for rotary-wing aircraft windscreens.

MIL-W-81752A(AS) requires a fixed windshield be provided forward of the cockpit. The windshield is to be designed "to provide clear vision for the pilot" and provide protection to the pilots and crewmen. Structural frames which impact external viewing from the cockpit are required to "avoid gunsight and optical landing aids viewing areas."

MIL-STD-850B establishes requirements for providing adequate external vision from within the cockpit for military aircraft. While requiring "the maximum practicable external vision be provided for the pilot(s)," MIL-STD-850B establishes minimum criteria. These criteria are based on monocular vision. Criteria vision angles are specified to a reference plane which is the pilot's horizontal vision plane as defined in MIL-STD-1333A. The zero reference in an azimuth is the straight ahead of the aircraft design eye position.

Tables 1 and 2 presents a summary of vision criteria for side-by-side and single/tandem piloted rotary-wing aircraft as cited in MIL-STD-850B, respectively. MIL-STD-850B should be consulted for specific criteria.

Documentation of Visual Ports

The initial step in the investigation was to document the visual ports in each of the fielded rotary-wing aircraft. This task was accomplished through photography of each aircraft and documenting the vision plots of each aircraft.

Visual plots

Verification of external vision requirements must be provided for the aircraft production configuration in accordance with MIL-STD-850B. A plot of the total vision envelope (180 degrees in azimuth and 90 degrees in elevation) is required based on data acquired using an angle measuring device (e.g., an engineering transit) located at the design eye position. Vision plots for all U.S. Army rotary-wing aircraft are presented in Appendix A. The areas of vision which are blocked by airframe structure are represented by darkened areas. Visual plots for the AH-1, CH-47, OH-6, OH-58A, and UH-1 are reproduced from USAASCOM Technical Report 73-1.

Table 1.

Rotary-wing vision criteria side-by-side pilot

Angle		Flight phase							Vision criteria
			Cruise		Combat				
Az	El	Taxi and takeoff	Navigation	Formation and air refuel	Search	TGT ACQ and WPN REL	Damage assess	Approach and landing	
0 - 45°	Up	4		3	2	1			When at a hover or accelerating (nose low altitude) the pilot should have an unobstructed view of terrain directly in front of the aircraft including obstacles in the flight path.
	Down	2	3	4	5	3		1	The landing area must be visible during the approach up to 35 feet in front of the aircraft including those portions of the approach requiring nose-high altitudes. Applicable to standard an nonstandard approaches.
46 - 90°	Up	1		3	3	3	4	2	Pilot must have an unobstructed view of the rotor tip path plane for obstacle clearance. Emphasis should be placed on being able to clear the aircraft during turns.
	Down	1	2	4	3	2	5	1	The pilot should be able to see the ground 5 feet from the aircraft when at a hover.
91 - 135°	Up	2			1	1		3	Pilot should be able to see a helicopter that is behind him for the air-to-air combat role.
	Down	2	3		1	1		4	Same as 46 - 90° down.
136 - 180°	Up	2			1	1		3	Same as 91 - 135° up.
	Down	1			3	2		1	Same as 46 - 90° down.

Note: Numbers shown under each flight phase column indicate applicability of that phase for establishing vision criteria within the azimuth angles shown, and relative priority (1 having the highest priority).

Table 2.

Rotary-wing vision criteria single/tandem pilot

Angle		Flight phase							Vision criteria
			Cruise		Combat				
Az	El	Taxi and takeoff	Navigation	Formation and air refuel	Search	TGT ACQ and WPN REL	Damage assess	Approach and landing	
0 - 45°	Up	1		5	3	2		1	When at a hover or accelerating (nose low altitude) the pilot should have an unobstructed view of terrain directly in front of the aircraft including obstacles in the flight path.
	Down	1	2	4	3	2	5	1	The landing area must be visible during the approach up to 35 feet in front of the aircraft including those portions of the approach requiring nose-high altitudes. Applicable to standard an nonstandard approaches.
46 - 90°	Up	1			2	2		1	Pilot must have an unobstructed view of the rotor tip path plane for obstacle clearance. Emphasis should be placed on being able to clear the aircraft during turns.
	Down	1	3		2	2		1	The pilot should be able to see the ground 5 feet from the aircraft when at a hover.
91 - 135°	Up	2			1	1	4	3	Pilot should be able to see a helicopter that is behind him for the air-to-air combat role.
	Down	2	4		1	1	5	4	Same as 46 - 90° down.
136 - 180°	Up	2			1	1	4	3	Same as 91 - 135° up.
	Down	2	5		1	1	4	3	Same as 46 - 90° down.

Note: Numbers shown under each flight phase column indicate applicability of that phase for establishing vision criteria within the azimuth angles shown, and relative priority (1 having the highest priority).

The visual plot for the AH-64 is reproduced from Hughes Helicopter AAH system specification AMC-SS-AAH-H10000A. The visual plot for the OH-58D is reproduced from Bell Helicopter Textron AHIP system specification AV-SS-NTSH-B10000. The visual plot for the TH-67 was provided by Bell Helicopter Textron.

It should be noted that during the summer months the OH-58 models often are flown without doors; the OH-6 is flown exclusively without doors.

Photography of visual ports

Figures 11-19 provide the front and side photographic views of each aircraft. From these photographs and those in Figures 1-10, an overview of the relative location and extent of each aircraft's visual ports can be obtained. Table 3 provides a detailed list of visual ports by individual aircraft.

To provide a pictorial representation of the external vision provided by each aircraft, photographs were taken from the cockpit using a Globuscope 360-degree 35-mm photographic system. Unlike a shutter driven cameras, this system takes a picture by scanning the scene through a thin slit. As the camera rotates, a continuous photographic image is formed onto the film. The resultant photographs are a continuous composite of an infinite number of views. The vertical field is 60 degrees.

The camera was mounted in the left seat of each cockpit, in a horizontal plane, facing forward, parallel to the fuselage reference line. As the photographs were intended only to be representative of available external vision, the vertical position of the camera was defined generally as at a point representative of the eye position of the photographer (male, 6 feet in height) when seated at a nominal seat height adjustment (when applicable). The resulting photographs are provided in Figures 20-30. Only the angular subtense encompassing the visual ports is shown. Aircraft structural parts that block monocular vision are apparent in the photographs.

The most significant observation which can be made from the photographs is the dramatic difference in the extent of external viewability between aircraft with tandem seating (e.g., AH-1 and AH-64) and those with side-by-side seating (e.g., CH-, OH-, and UH- models); the tandem seating configuration provides excellent over-the-nose and lateral vision for the front seat copilot/gunner.

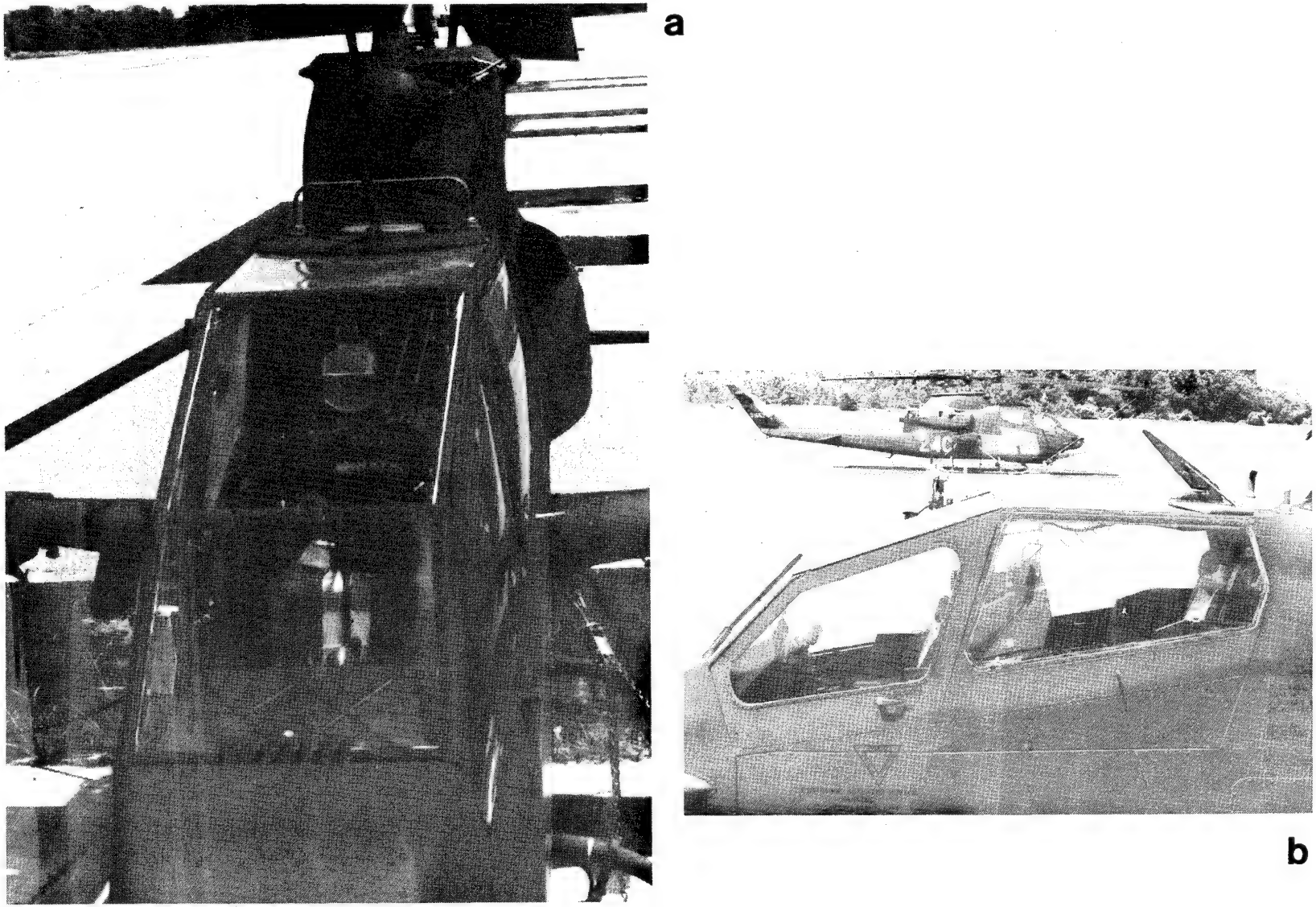


Figure 11. AH-1S/F Cobra views: a) front windscreens; b) left side.

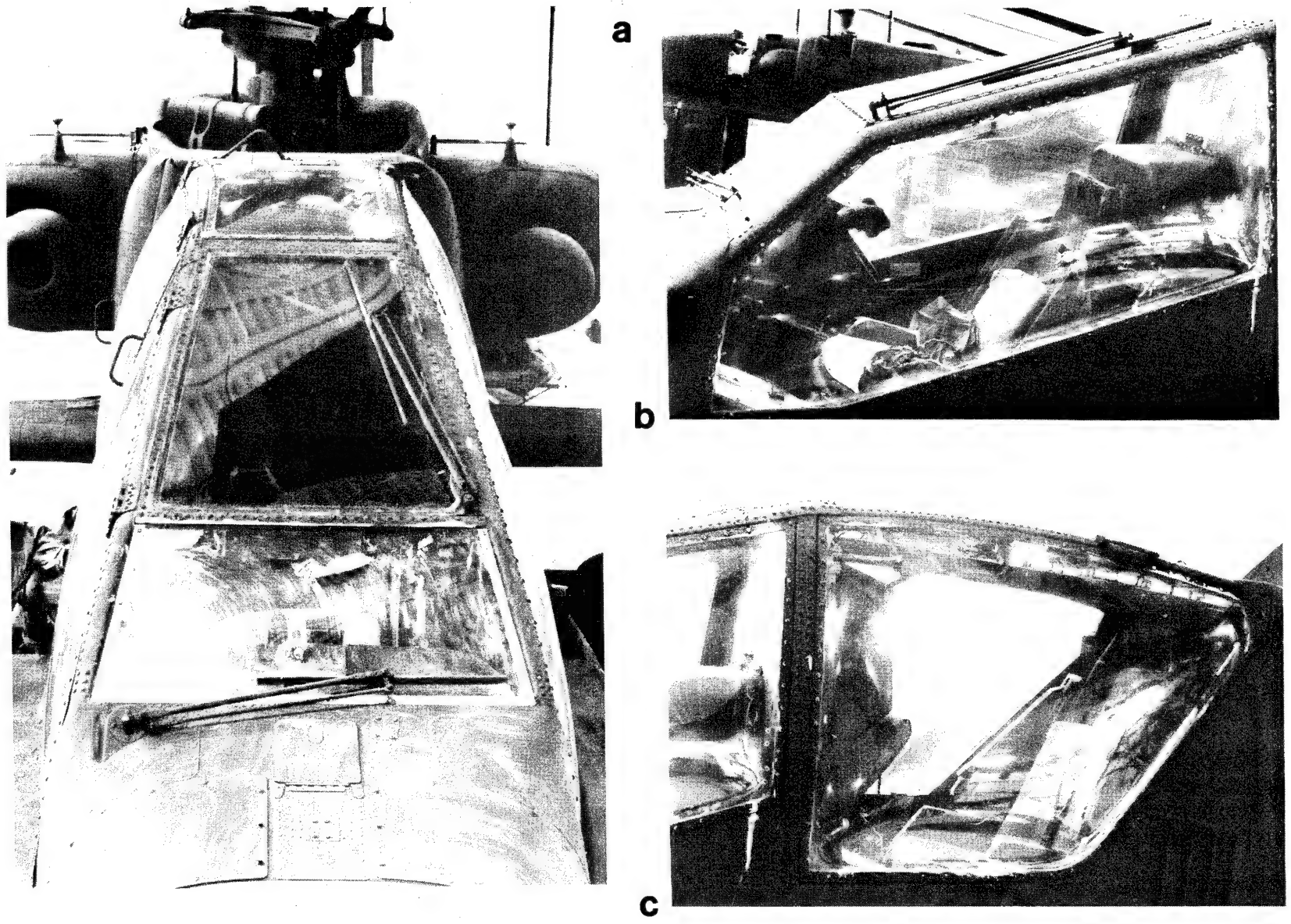


Figure 12. AH-64 Apache views: a) front windscreens; b) window, left front; c) window, left rear.

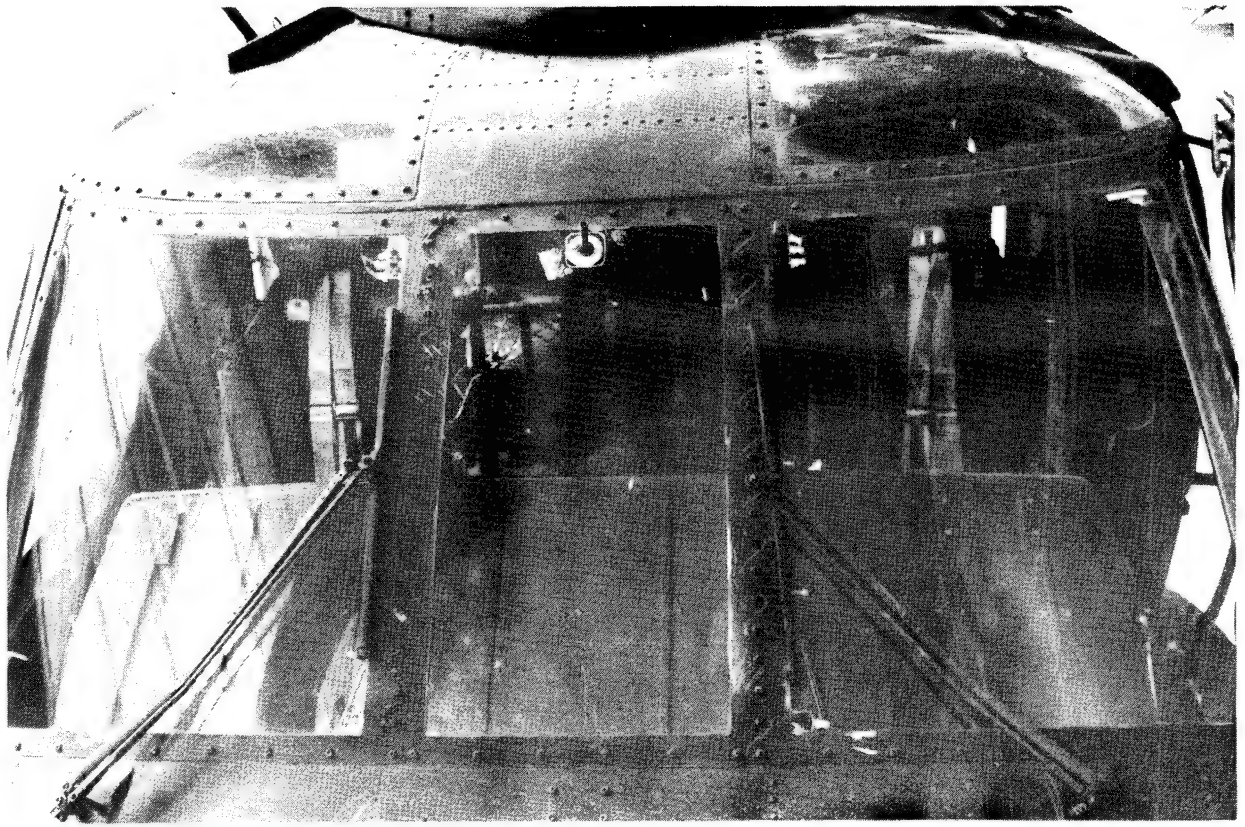


Figure 13a. CH-47D Chinook view of front windscreens.

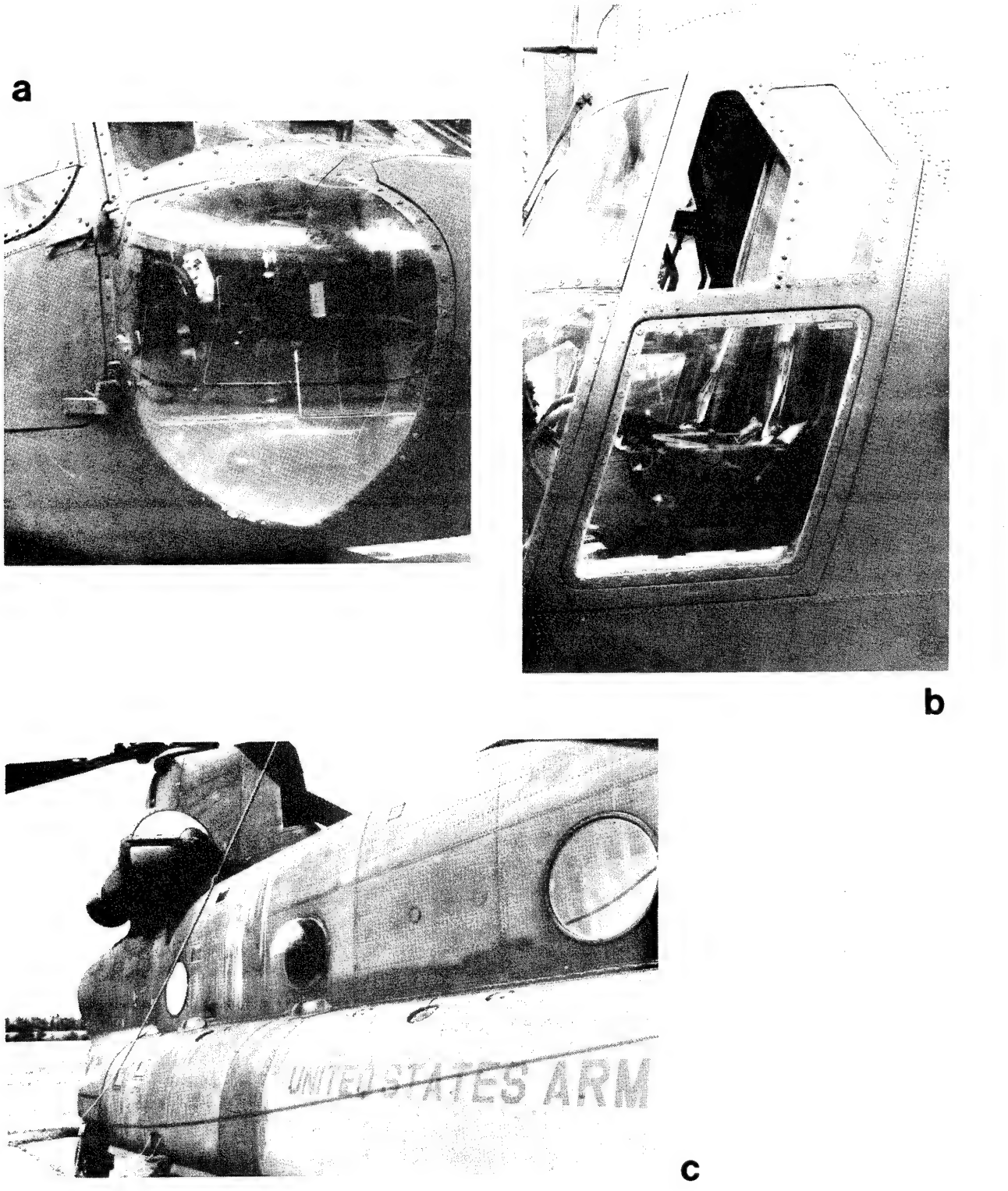


Figure 13b. CH-47D Chinook views: a) chin bubble, right; b) windows, (fire escape) left front; c) windows, rear, with bubble .

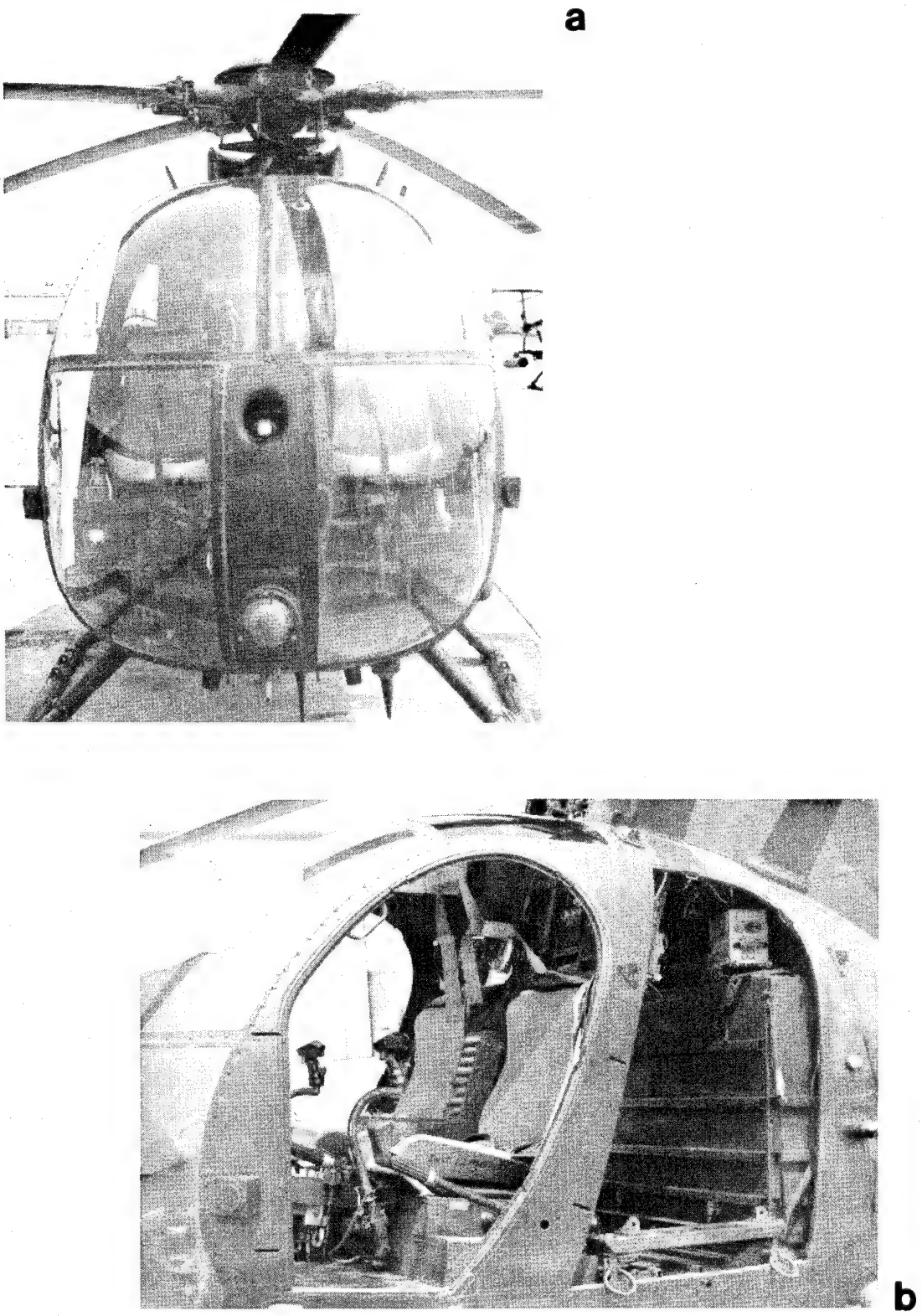


Figure 14. OH-6 Cayuse views: a) front windscreens; b) side, with doors removed.

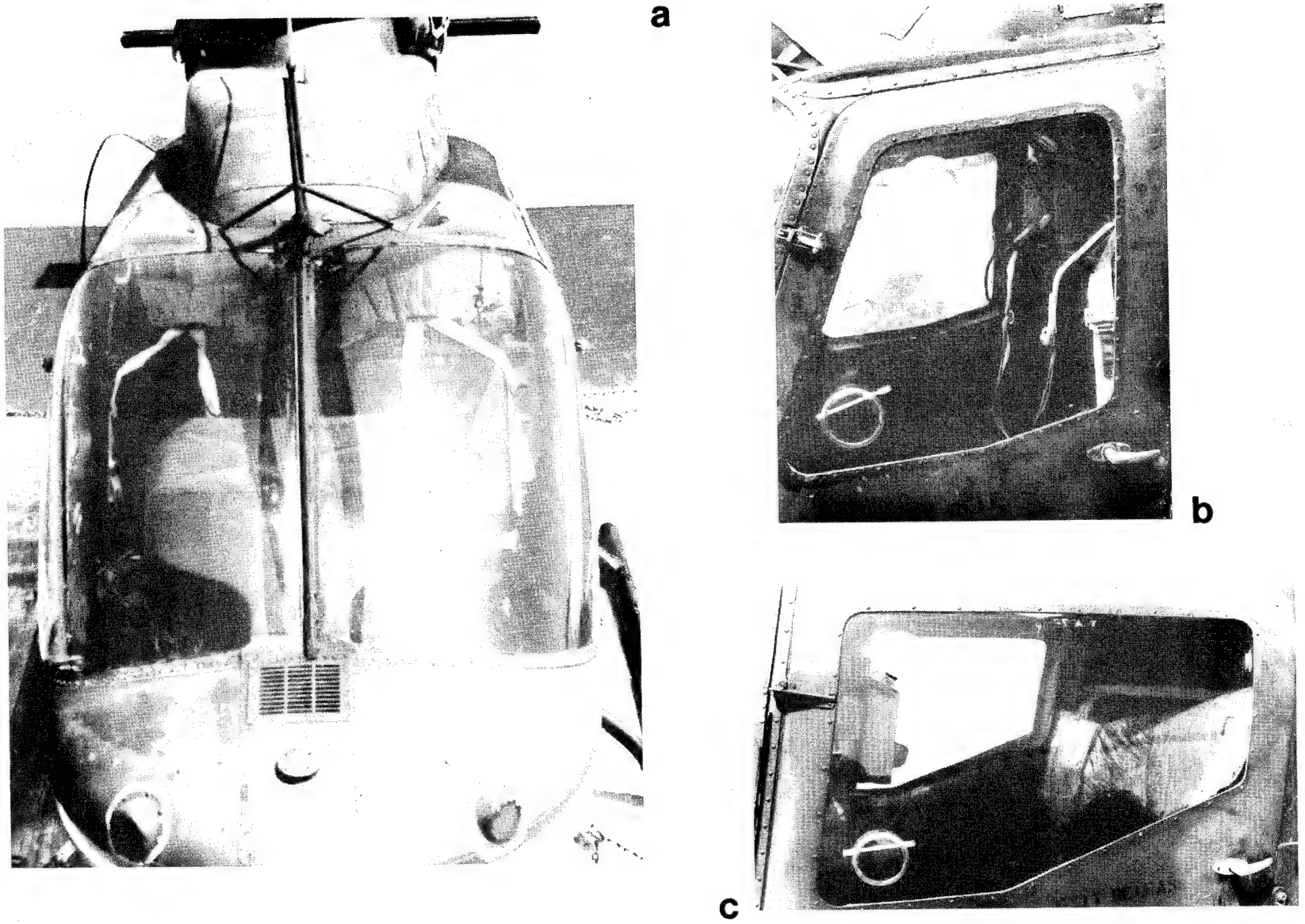


Figure 15. OH-58A/D Kiowa views: a) front windscreens; b) window, left front door; c) window, left rear door.

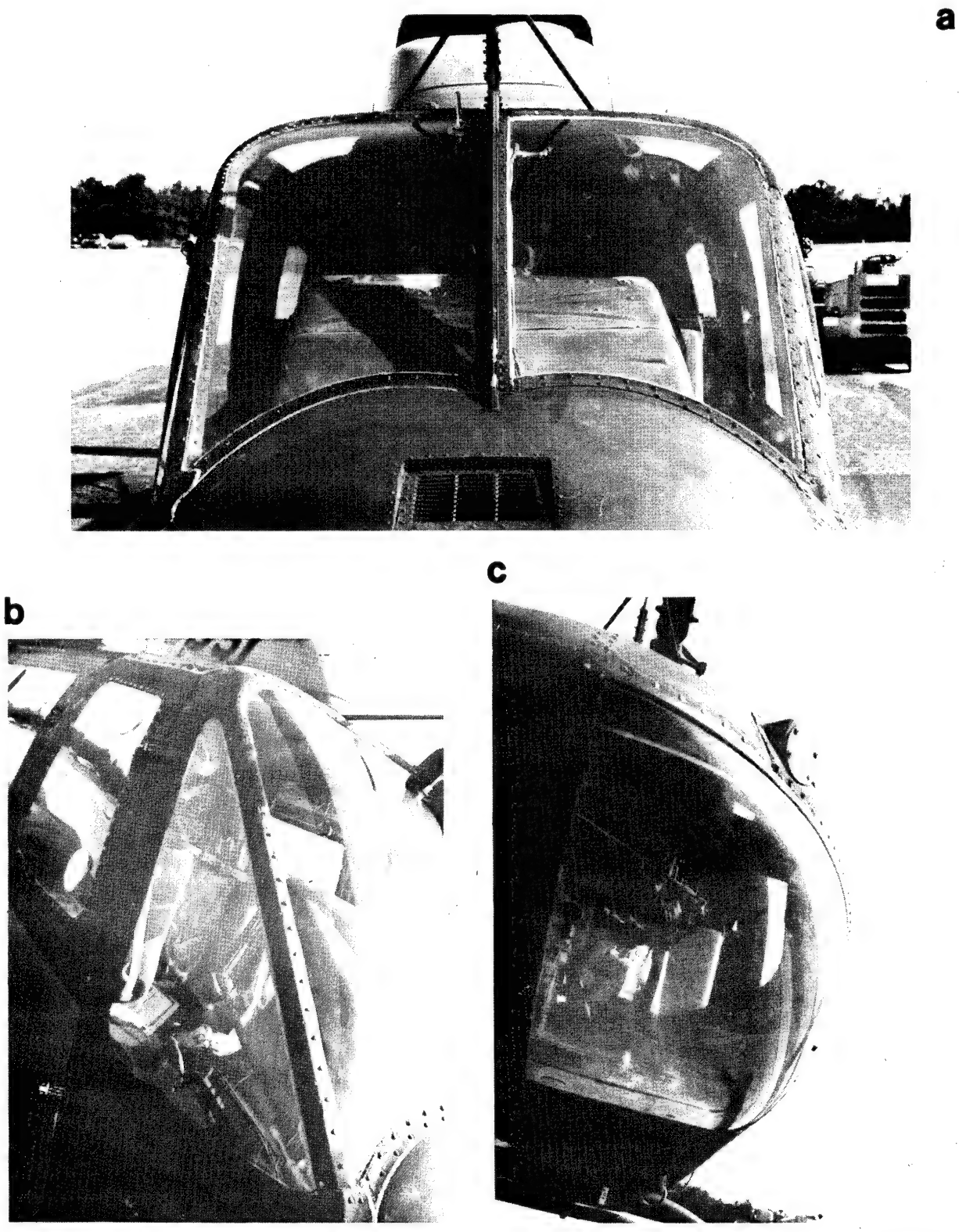


Figure 16. OH-58C Kiowa (flat panel) views: a) front windscreens; b) windows, right view of front and rear doors; c) left chin bubble.

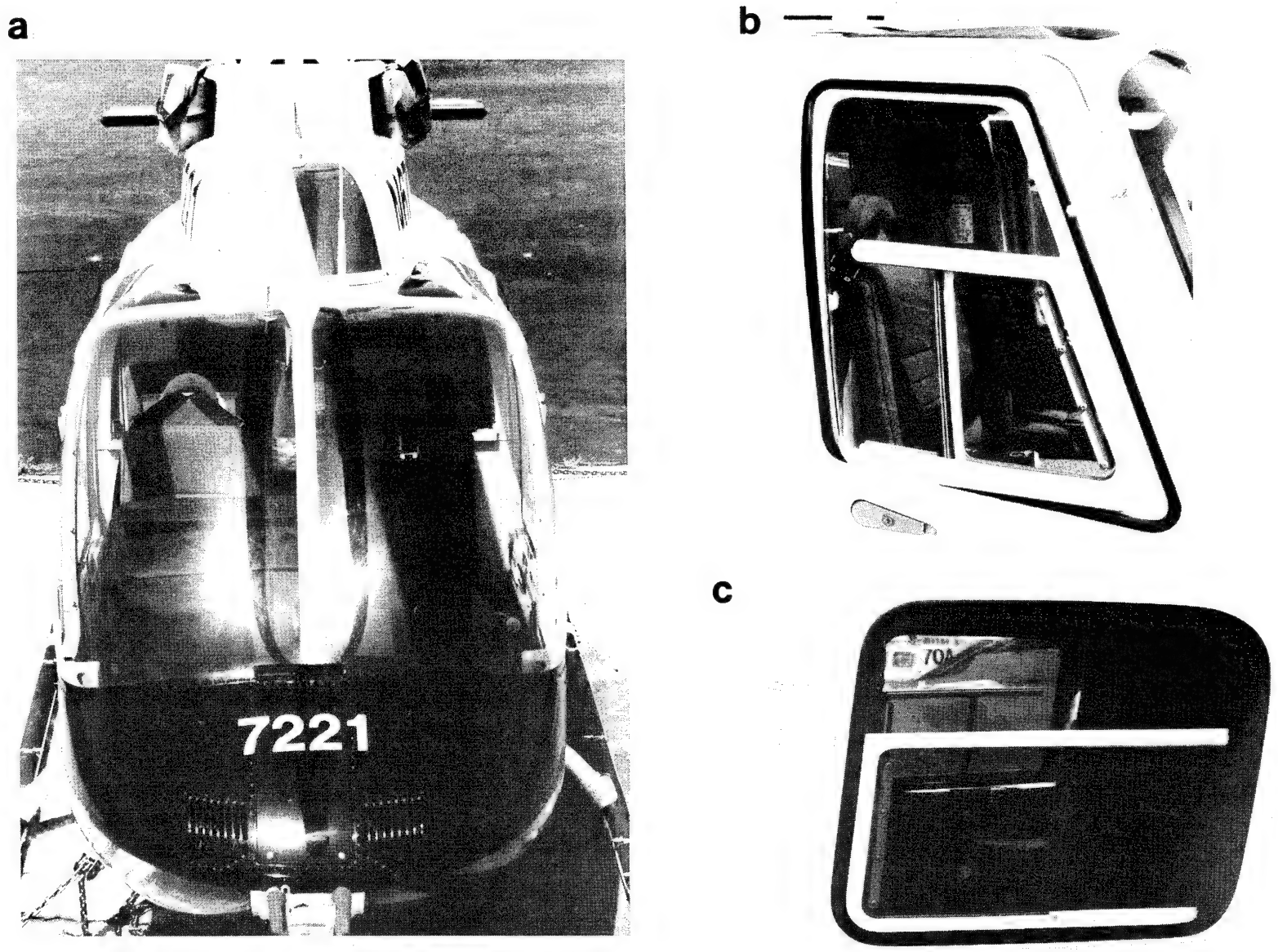


Figure 17. TH-67 Creek views: a) front windscreens; b) windows, right front door; c) and windows, left rear door.

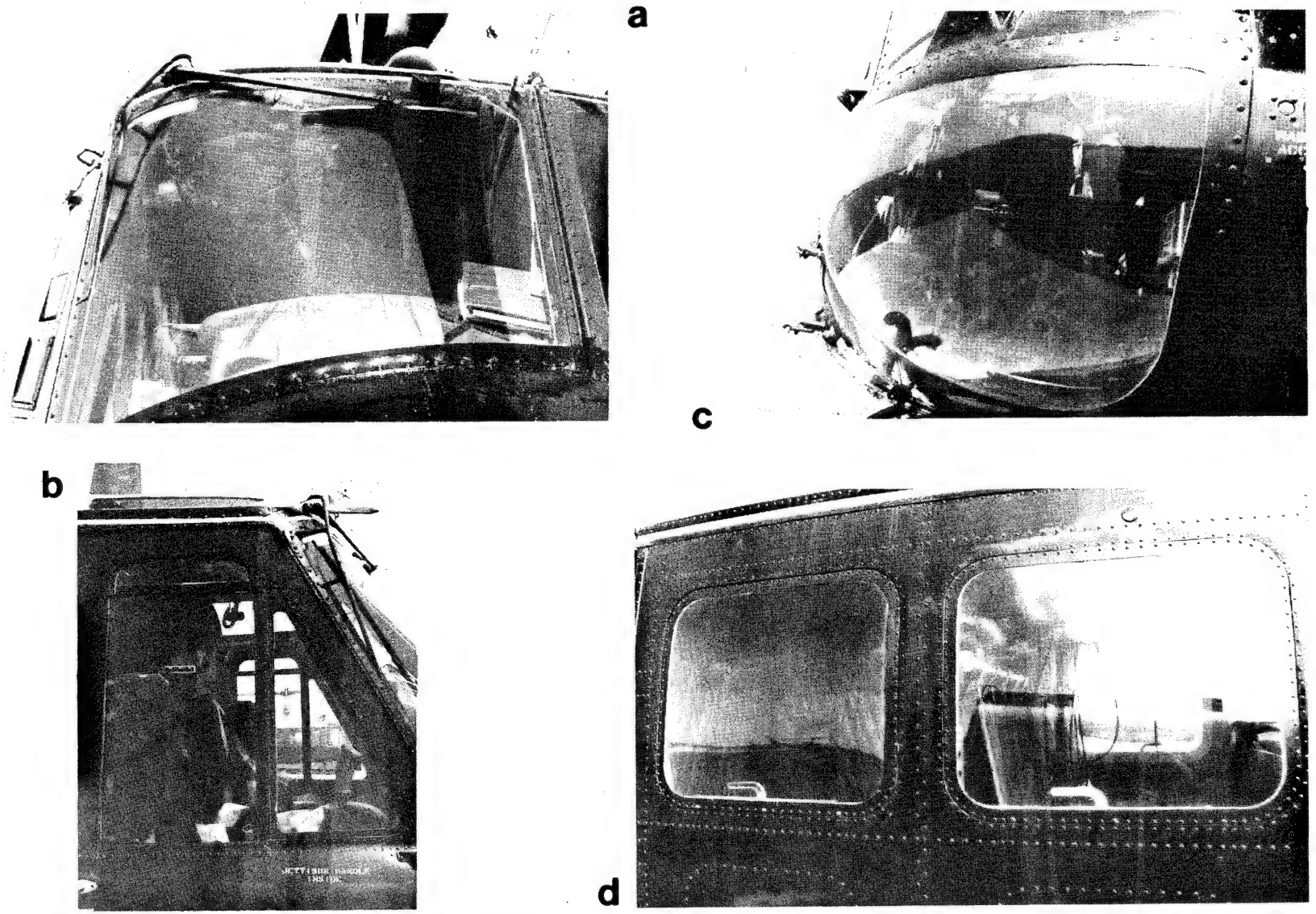


Figure 18. UH-1H Iroquois views: a) front windscreen, right; b) chin bubble, right; c) windows, right front door; d) windows, right cargo door.

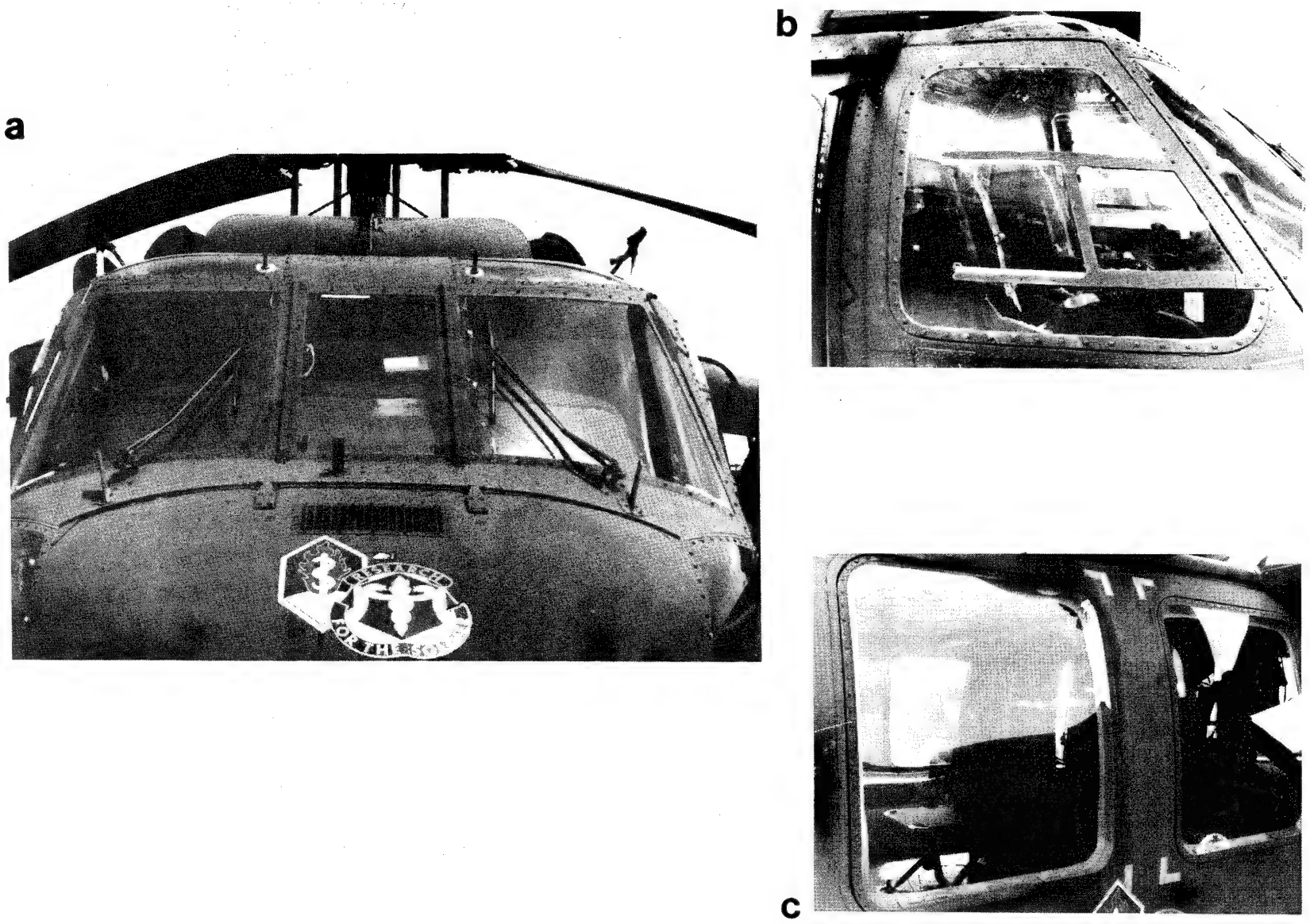


Figure 19. UH-60A Black Hawk: a) front windscreens; b) windows, right front door; c) windows, right cargo door.

Table 3.

List of visual ports by aircraft.

Aircraft type/model	Port description
AH-1S/F (Fig. 1, 11)	Front windscreen Front overhead windscreen Front side windows, left, right Rear overhead windscreen Rear side windows, left, right
AH-64 (Fig. 2, 12)	Lower front windscreen Upper front windscreen Front side windows, left, right Rear overhead window Rear side windows, left, right
CH-47D (Fig. 3, 13)	Front center windscreen Front windscreens, left, right Front overhead windows, left, right Chin bubbles, left, right Front side panels, left(3), right(3) Side window, left Side door window, right Side windows circular, left(3), right(3) Side bubble windows, left, right
OH-6 (Fig. 4, 14)	Front windscreens, left (top and bottom) Front windscreens, right (top and bottom) Front side door windows*, left, right Rear side door windows*, left, right Overhead windows, left, right

* Doors are often removed for flight.

Table 3 (Continued).

List of visual ports by aircraft

Aircraft type/model	Port description
OH-58A (Fig. 5, 15)	Front windscreens, left, right Front side door windows*, left, right Chin bubbles, left, right Rear side door windows, left, right Overhead windows, left, right
OH-58C (Fig. 6, 16)	Front windscreens, left, right Front side door windows*, left, right Chin bubbles, left, right Rear side door windows*, left, right Overhead windows, left, right
OH-58D (Fig. 7, 15)	Front windscreens, left, right Chin bubbles, left, right Side door windows*, left, right Overhead windows, left, right
TH-67 (Fig. 8, 17)	Front windows, left, right Overhead windscreens, left, right Chin bubbles, left, right Front door windows, left(2), right(2) Rear door windows, left(2), right(2)
UH-1H (Fig. 9, 18)	Front windscreens, left, right Front door window panels, left(3), right(3) Side windows, left, right Cargo door windows, left(2), right(2) Chin bubbles, left, right Overheads, left, right

* Doors often removed for flight.

Table 3 (Continued).

List of visual ports by aircraft

Aircraft type/model	Port description
UH-60A (Fig. 10,19)	Front windscreens, left, right Front center windscreen Chin bubbles, left, right Front door window panels, left, right Side windows, left(2), right(2) Cargo door windows, right(2), right(2) Overhead windows, left, right

* Doors often removed for flight.

Utilization questionnaires

Aviator and aircrew opinion on the utilization and acceptance of current rotary-wing aircraft visual port design was investigated through the use of written questionnaires. The questionnaires gave the users the opportunity to report their experiences and express their opinions on the external viewability of current operational helicopters. Separate questionnaires were developed for, and distributed to, pilot/copilots and aircrew. See Appendices B and C, respectively. [Note: Since the TH-67 is a training aircraft and is not fielded by the U.S. Army, questionnaire data were not collected for this aircraft.]

The pilot/copilot questionnaire requested aviator assessment of the adequacy of current visual port size and placement, parameters which define available external vision. Respondents also were questioned as to tasks performed through each visual port. Additional questions addressed pilot/copilot appraisals of problems associated not only with the size and location of visual ports, but also with optical quality, e.g., haze, distortion, etc. The aircrew questionnaire investigated those issues above which pertained primarily to the aircrew who perform tasks in the passenger or cargo compartments of nonattack aircraft.

Respondents were requested to base their responses on the aircraft type which they had flown the greatest number of hours during the last 6-month period. Additional questionnaires could be completed as necessary for other aircraft flown by the respondent.

Questionnaires were distributed to aviators and crew from Fort Rucker, Alabama, Fort Hood, Texas, Fort Benning, Georgia, Fort Bragg, North Carolina, and Fort Campbell, Kentucky. A total of 273 pilot/copilot and 71 crew questionnaires were completed.

Questionnaire data

Pilot/copilot and aircrew questionnaire data summaries are provided in Appendices D and E, respectively. The demographics of the questionnaire respondents are presented in Tables 4 and 5. The number of respondents by sex, crew function, and aircraft are reported. In addition, the total number of flight hours, combined by function and aircraft, is presented. For attack aircraft, i.e., AH-1 and AH-64, the demographics and flight hour data are categorized as pilot and copilot/gunner (Table 4). Tandem seating is employed in these aircraft with specific tasks assigned to the front and back seat aviators. For nonattack aircraft, e.g., utility, cargo, reconnaissance, etc., there is little division of tasks between pilot and copilot. Therefore, for the purpose of this study the pilot and copilot data are combined for the nonattack aircraft. [Note: This was a consequence of most questionnaire respondents marking both pilot and copilot as their primary station.] Crewman data are reported separately. These data represent the combined experience of 528,230 pilot/copilot and 54,000 crewman aircraft specific flight hours.

Questionnaire findings

The utilization questionnaire data were analyzed regarding overall viewability, visual port usage, windscreen problems, seating preference, etc. using the following scheme. First, data were grouped into pilot/copilot and crewmen data and then analyzed by specific aircraft. Data for copilots/gunners in attack aircraft were analyzed separately. Second, data were collapsed across all aircraft and analyzed for trends and particular conclusions. These were reported as general findings.

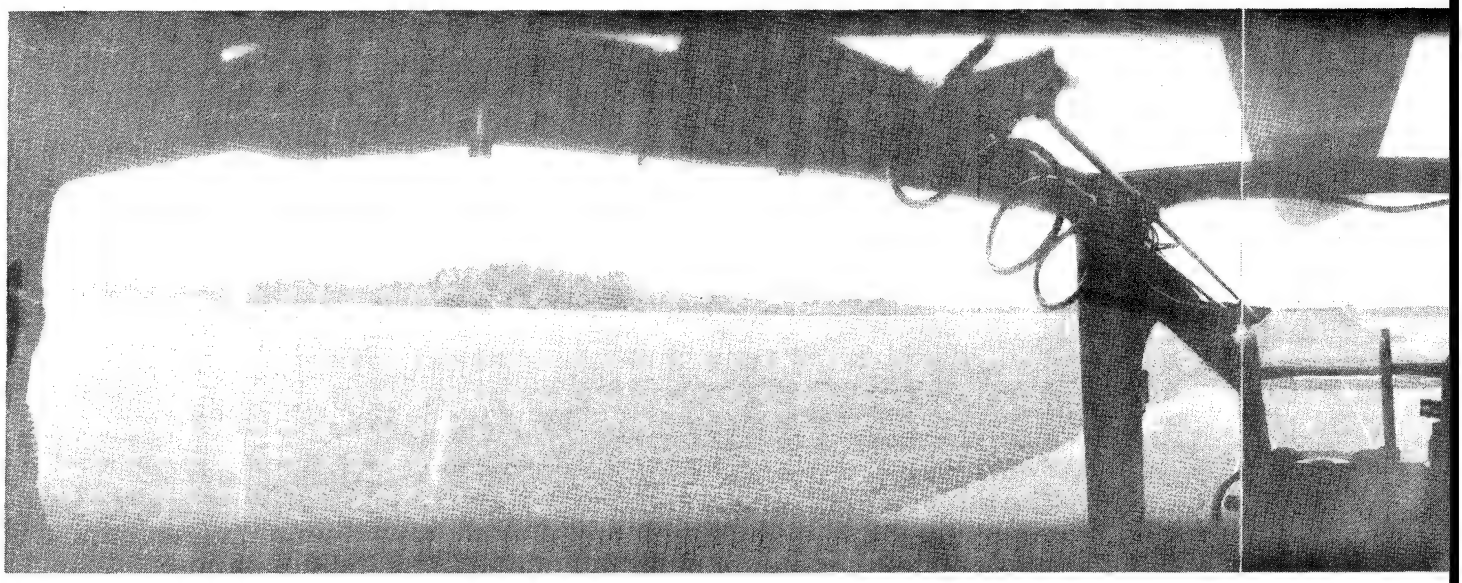


Figure 20. 360-degree photograph for AH-1S/F Cobra.

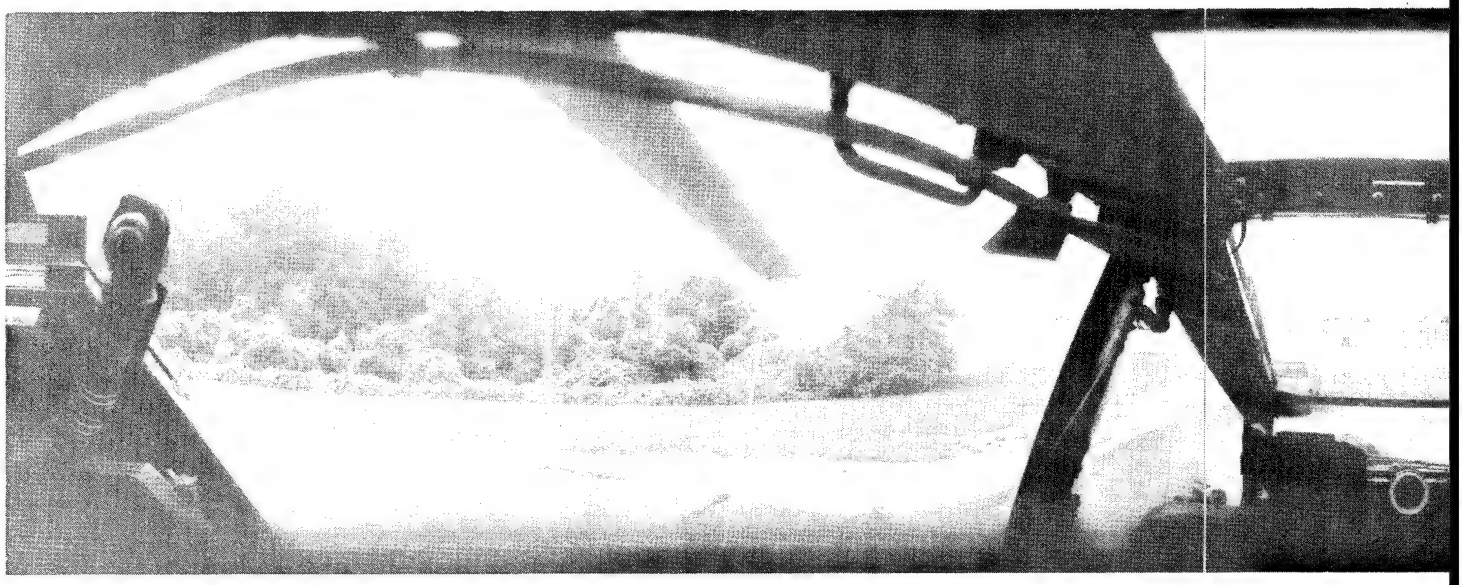
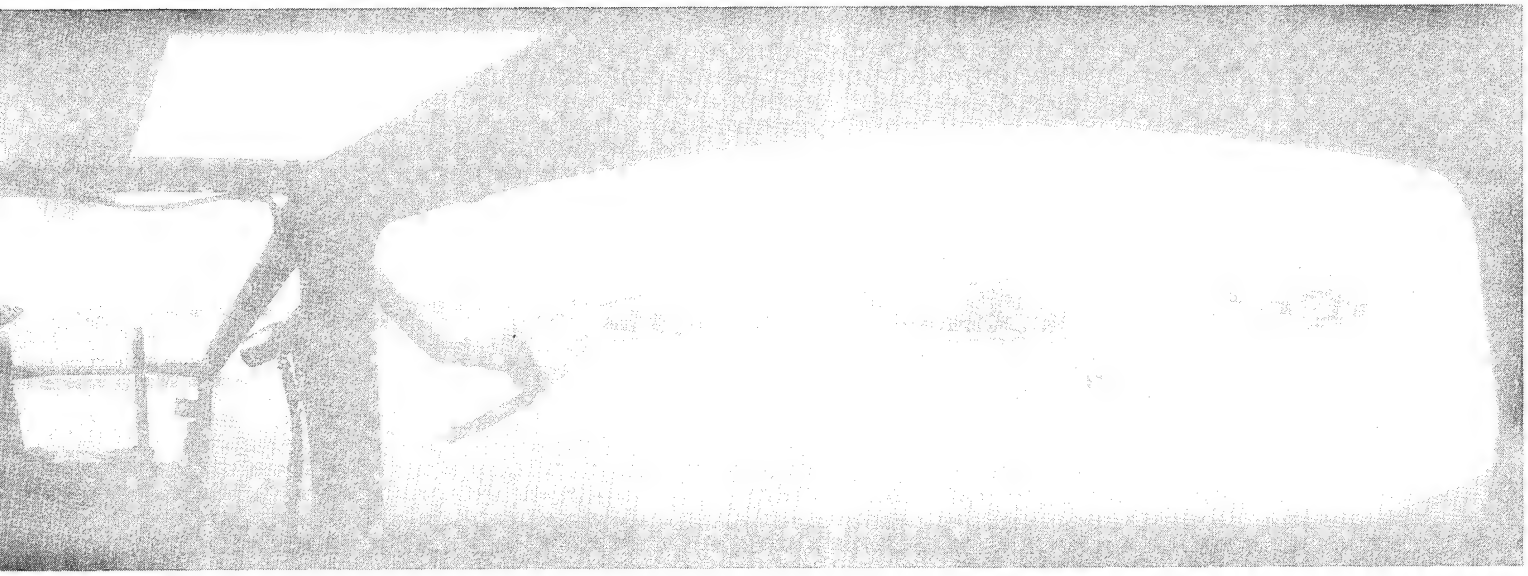
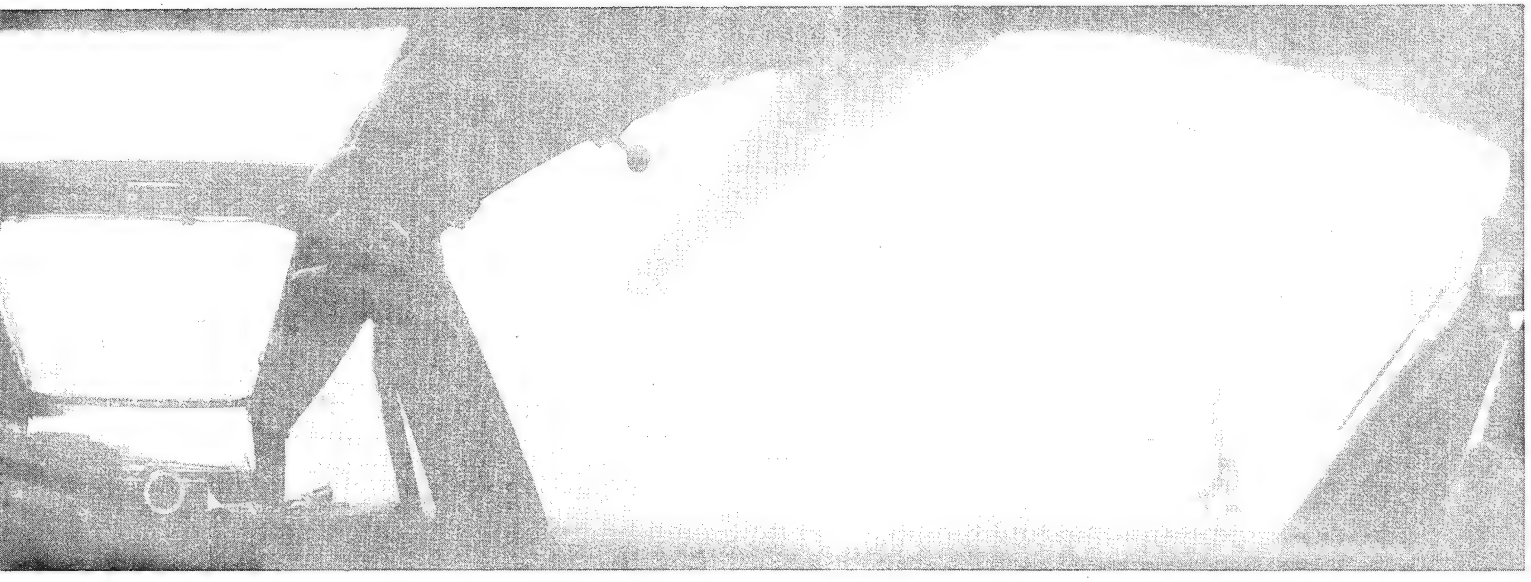


Figure 21. 360-degree photograph for AH-64 Apache.





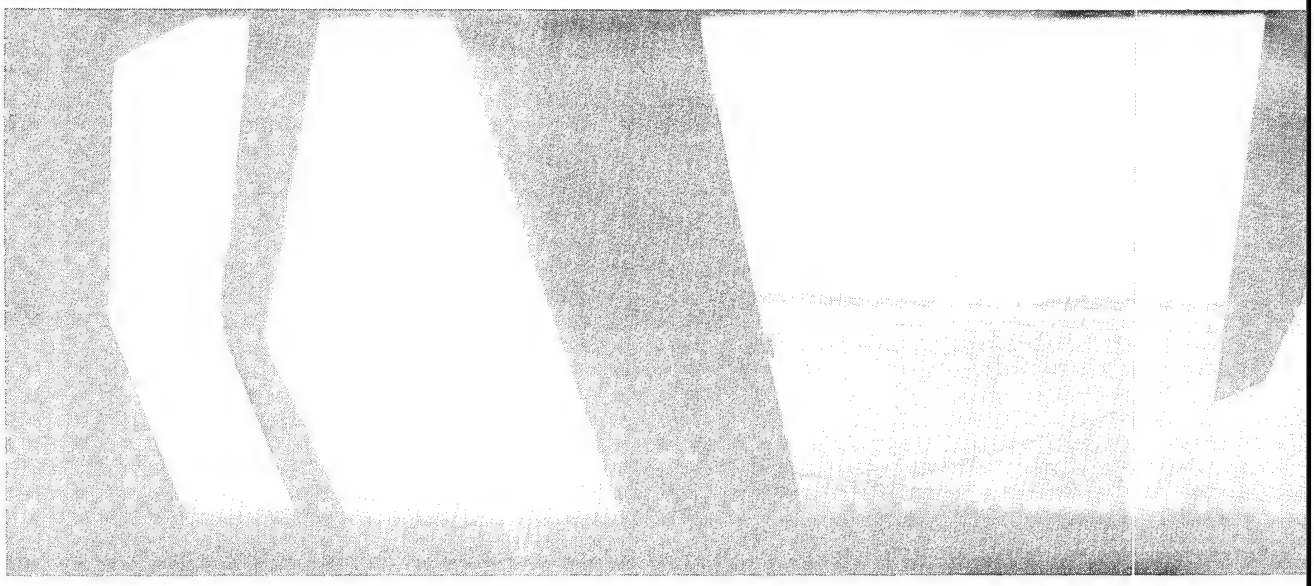


Figure 22. 360-degree photograph for CH-47D Chinook.

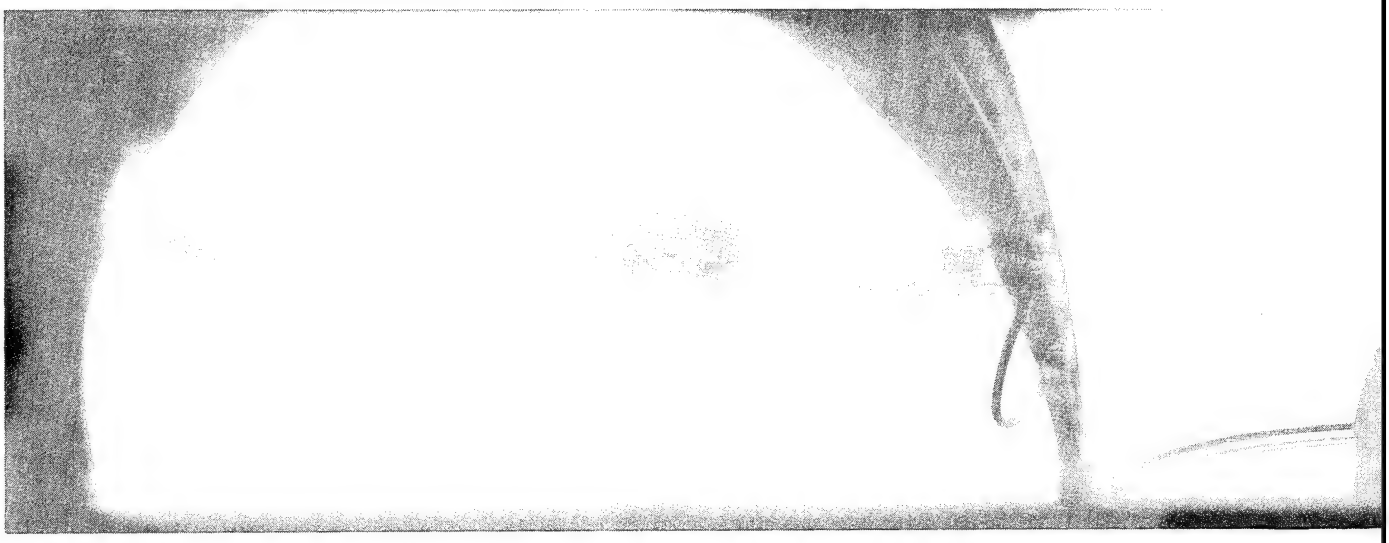
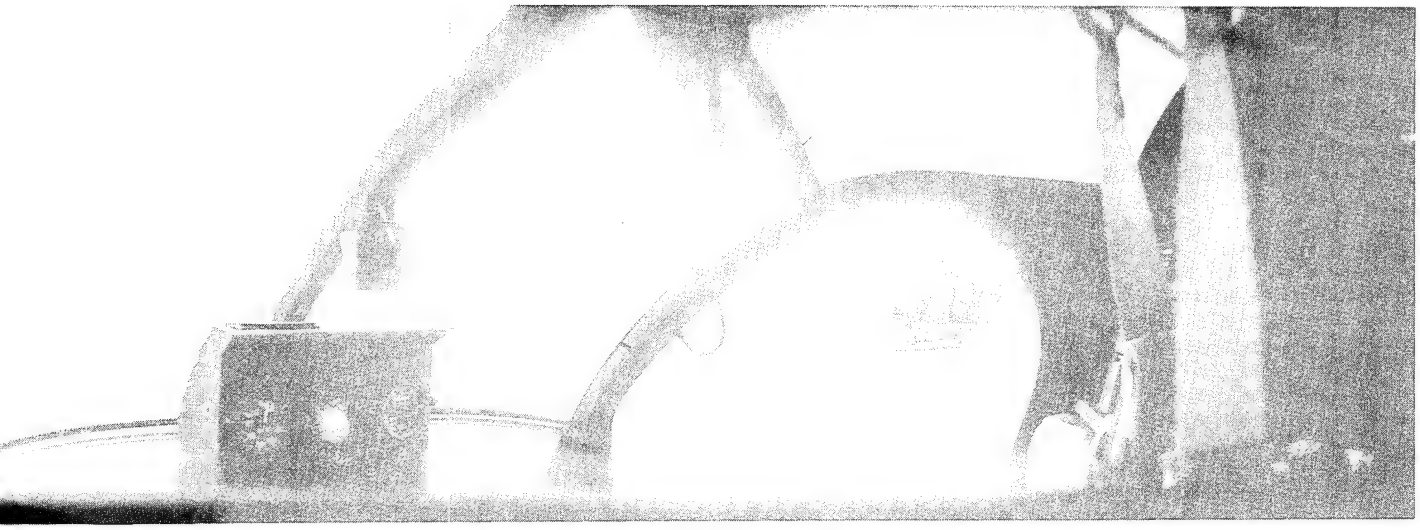


Figure 23. 360-degree photograph for OH-6 Cayuse.



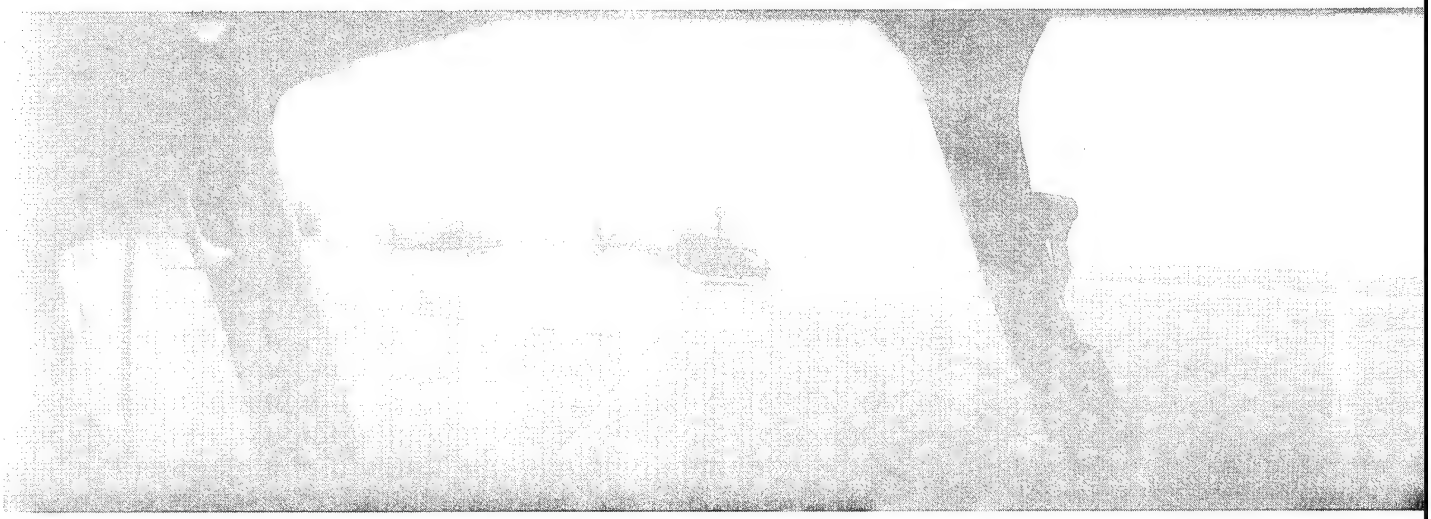


Figure 24. 360-degree photograph for OH-58A Kiowa.

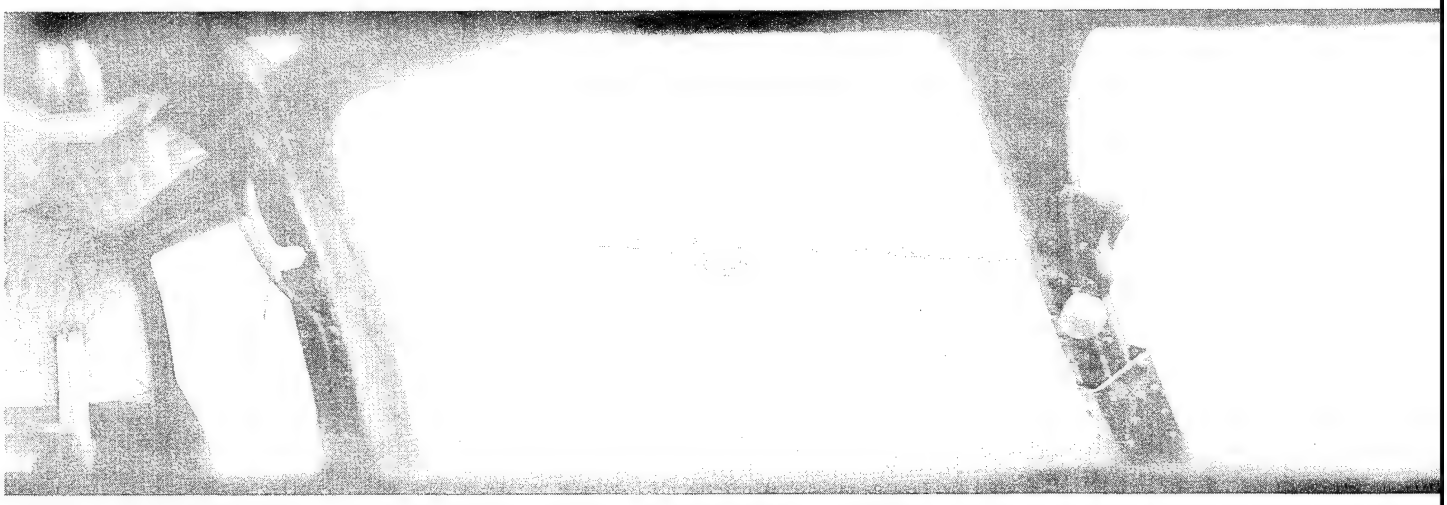
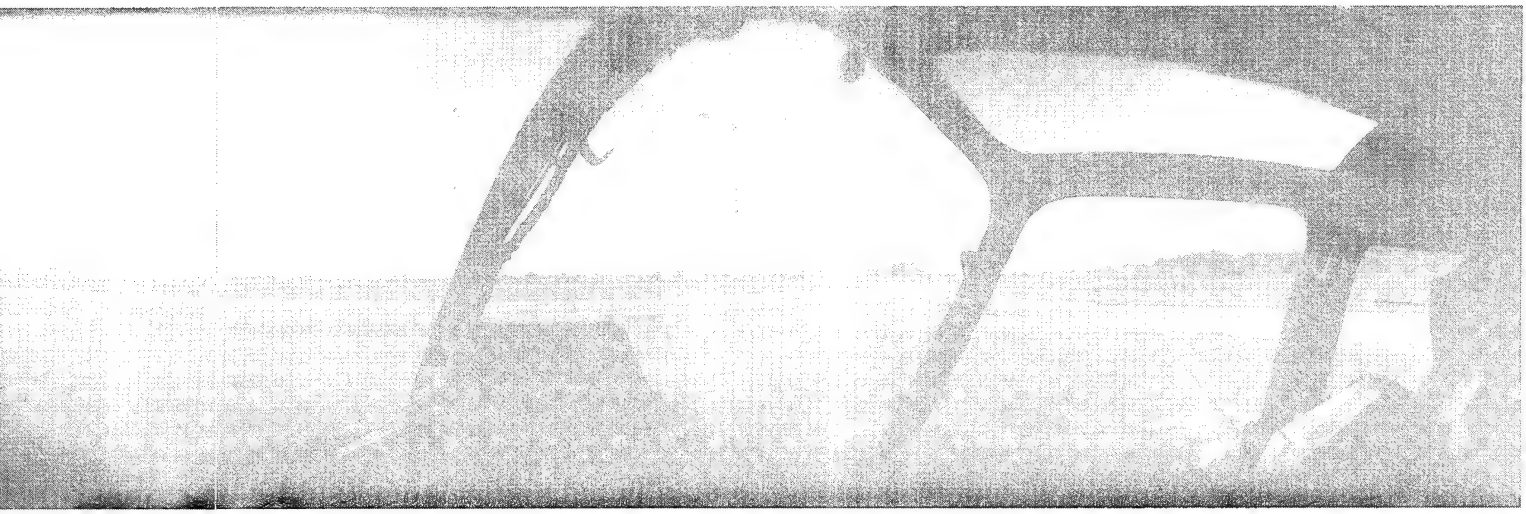
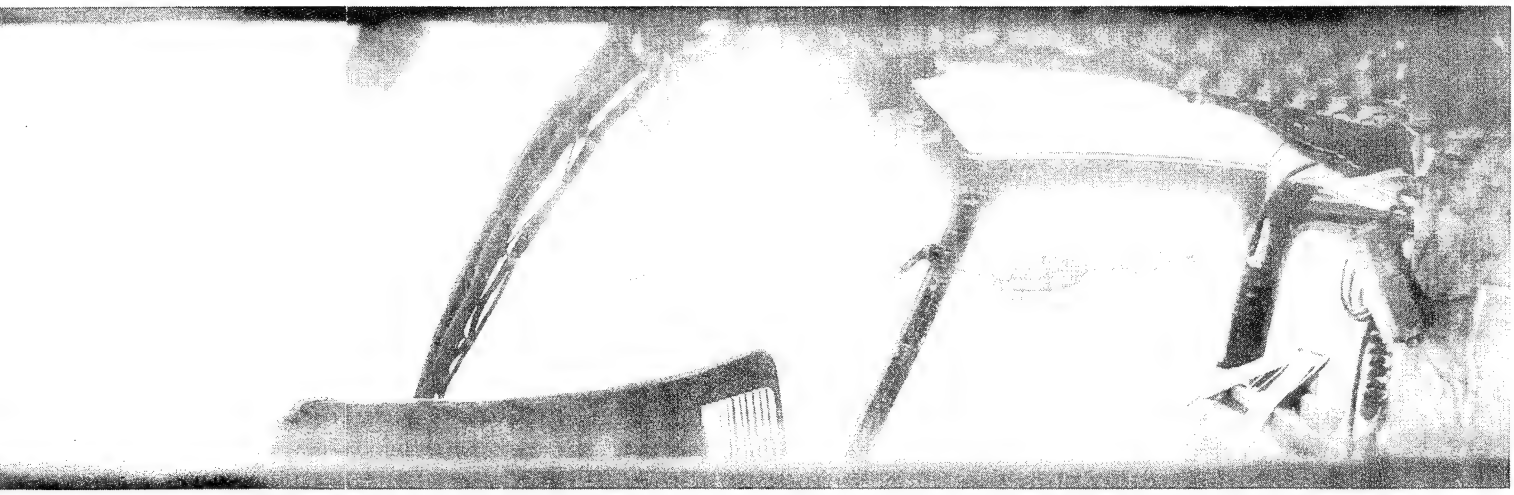


Figure 25. 360-degree photograph for OH-58C Kiowa.





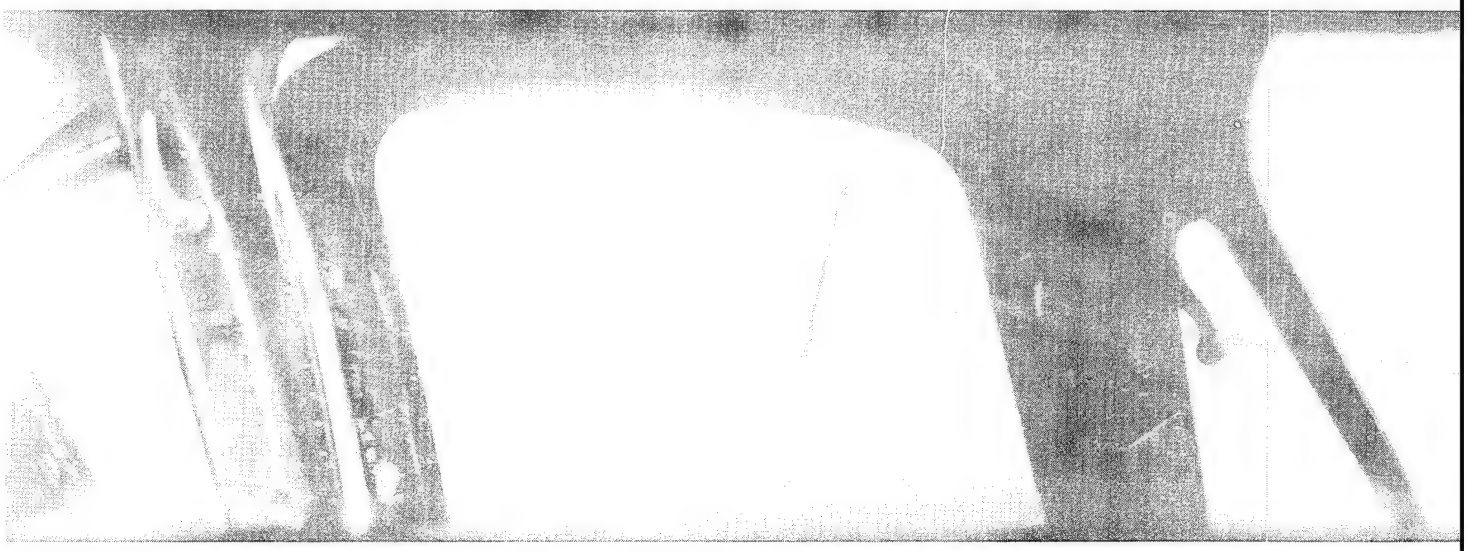


Figure 26. 360-degree photograph for OH-58C Kiowa (flat panel).

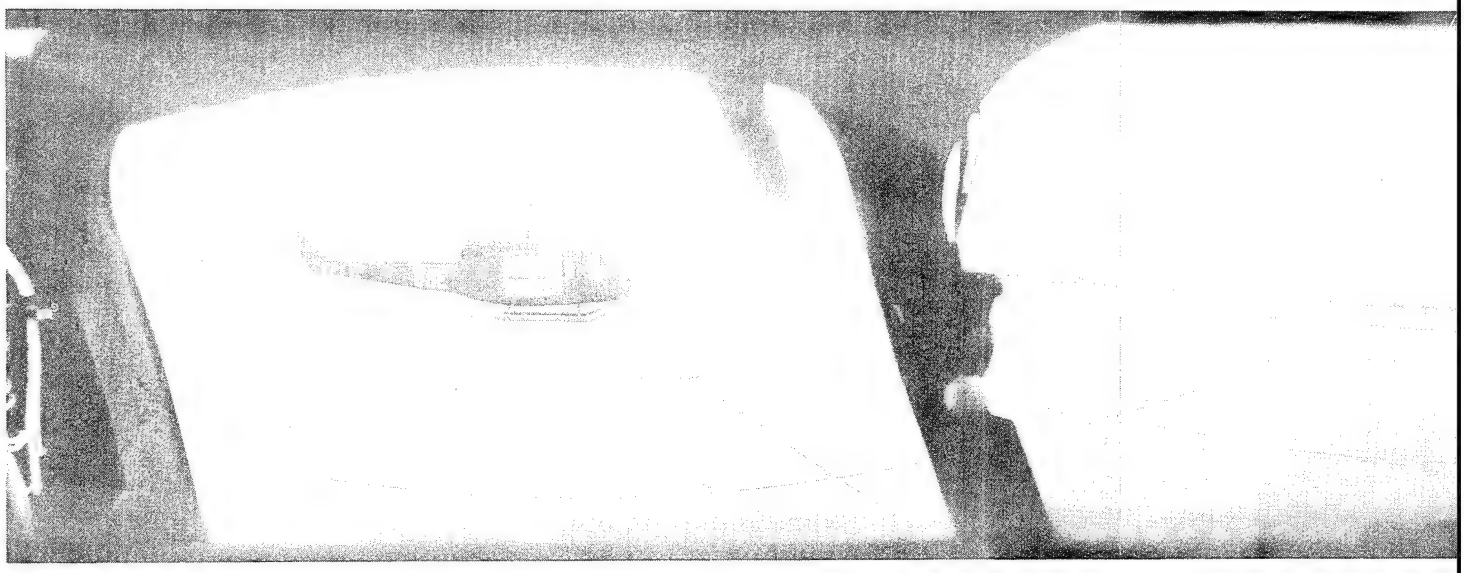
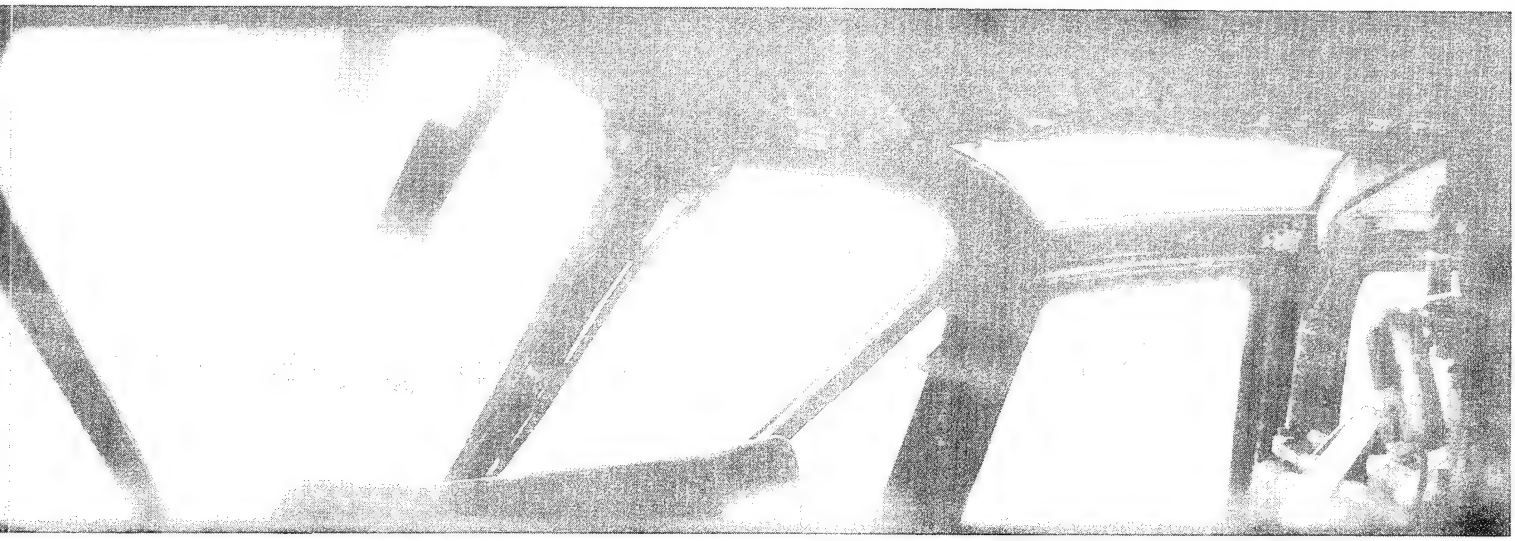
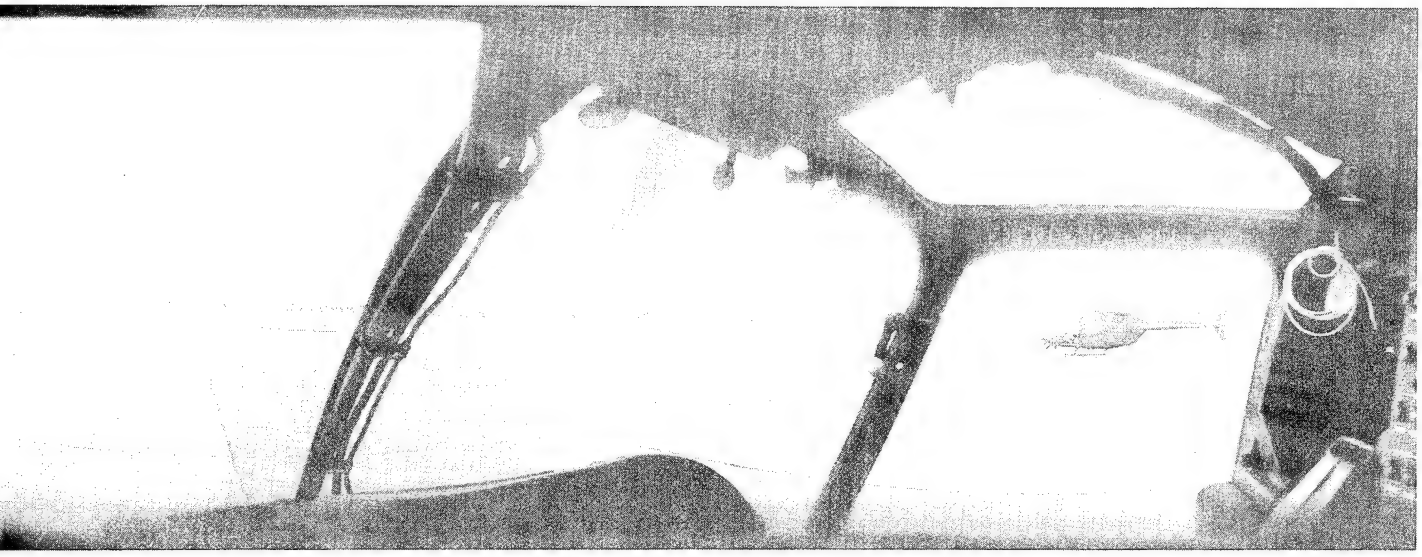


Figure 27. 360-degree photograph for OH-58D Kiowa.





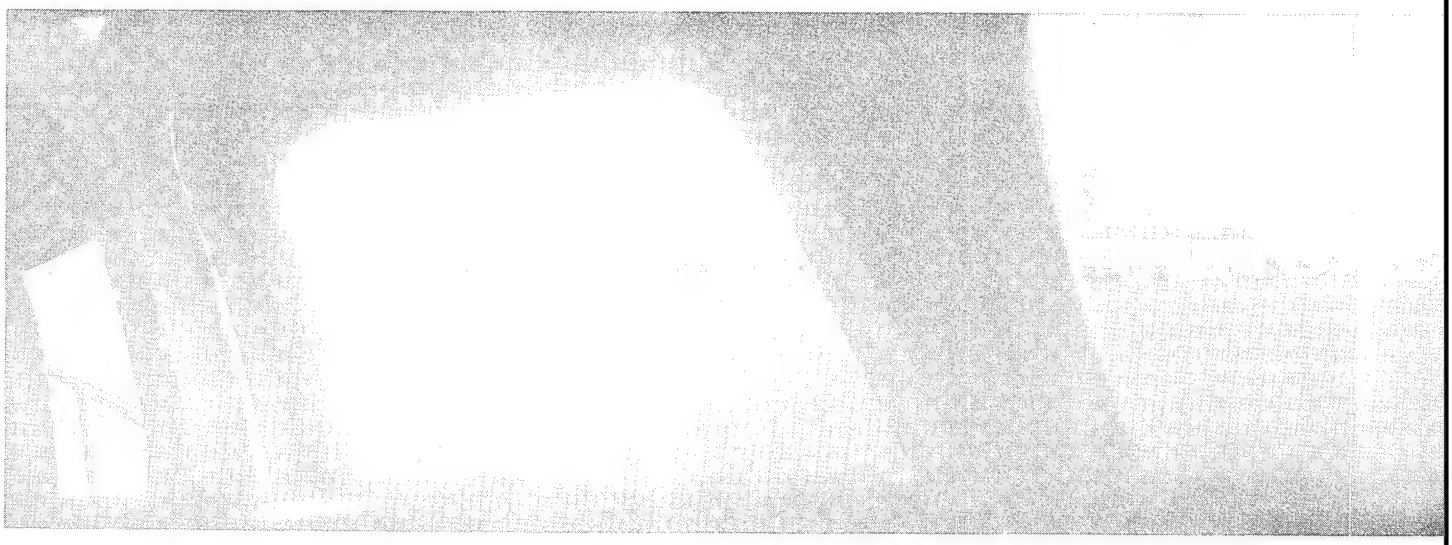


Figure 28. 360-degree photograph for TH-67 Creek.

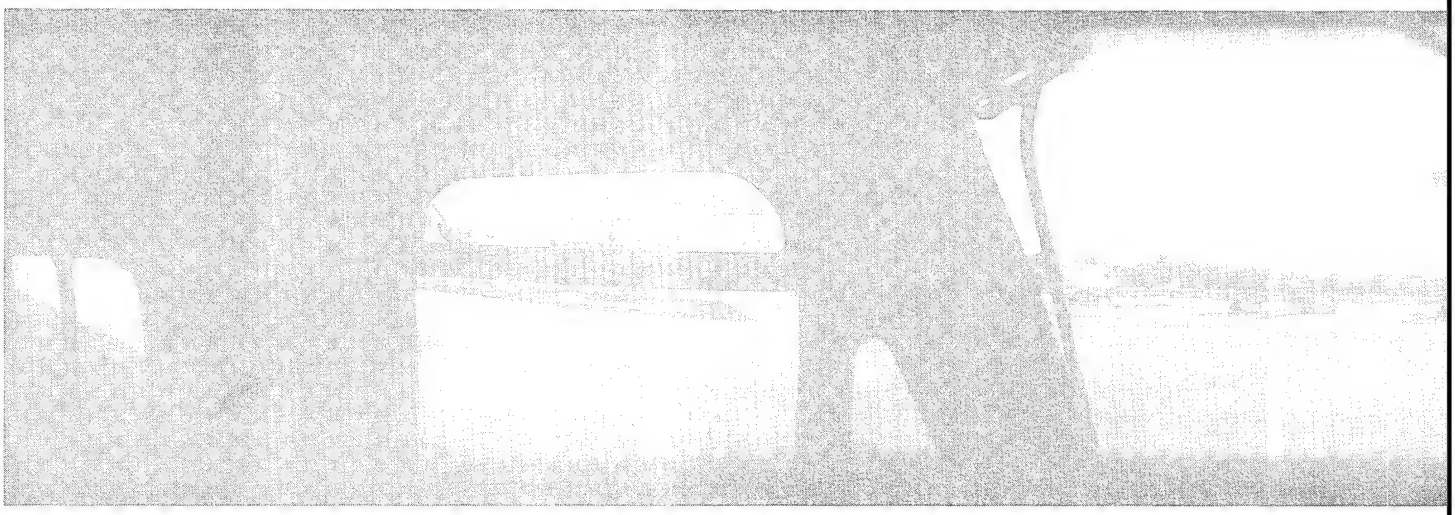
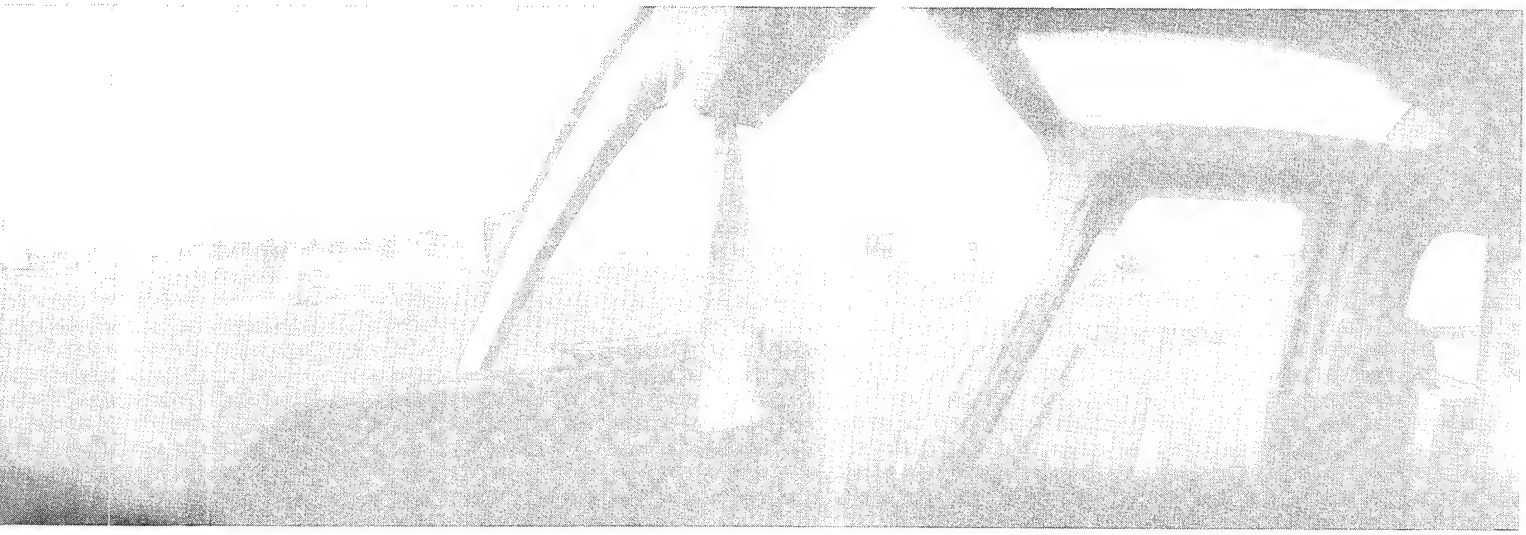


Figure 29. 360-degree photograph for UH-1H Iroquois.



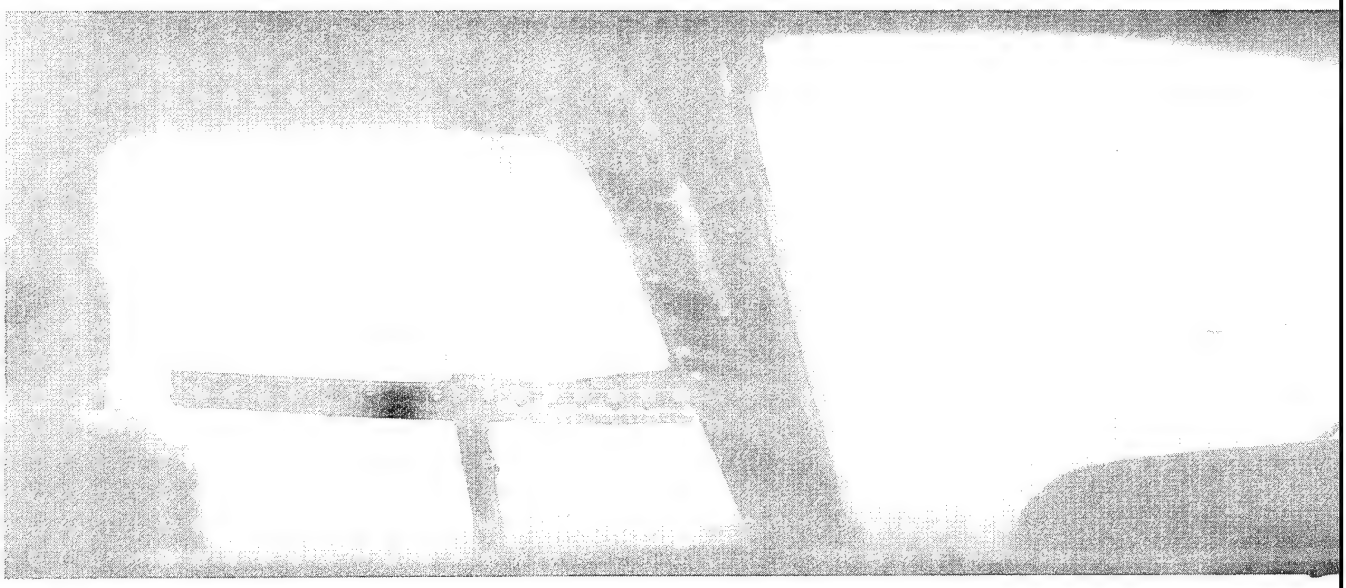


Figure 30. 360-degree photograph for UH-60A Black Hawk.

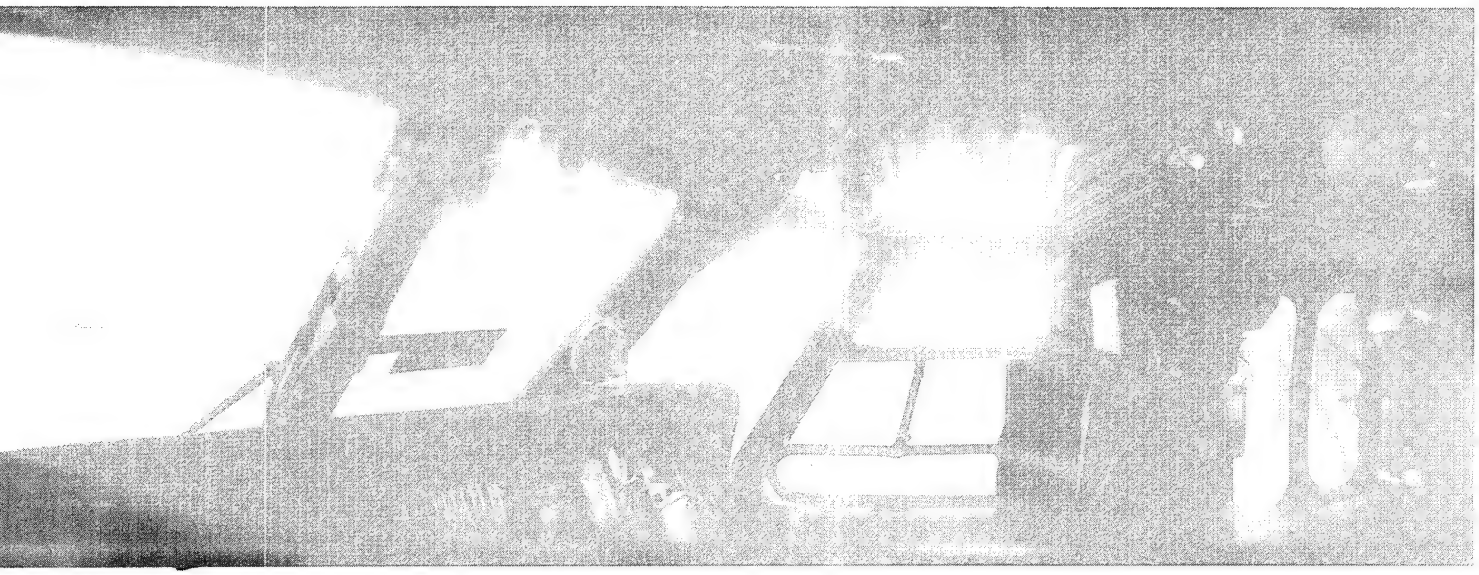


Table 4.

Demographics of utilization questionnaire respondents
for AH-1 and AH-64 attack aircraft.

Aircraft type	Sex	n	Pilot flight hours		n	Copilot\gunner flight hours	
			Aircraft	Total		Aircraft	Total
AH-1	M	7	3,580	4,565	4	6,880	9,940
	F	0	0	0	0	0	0
AH-64	M	30	18,980	43,300	11	2,515	9,420
	F	0	0	0	0	0	0
Totals	M	37	22,560	47,865	15	9,395	19,360
	F	0	0	0	1	170	570

Note: All flight hours are approximate.

General findings

When data were collapsed across all aircraft and analyzed, the following general findings were noted:

Pilot/copilot

• A majority of pilots, 55 percent (141 of 257), rated the external viewability of their respective aircraft as "good" to "very good." Thirteen percent (33 of 257) rated the aircraft viewability as "poor" to "very poor."

• The front windscreens are used for all visual tasks in all flight phases, however to a lesser extent for targeting tasks (except, as would be expected, for the attack aircraft).

• The side windscreens are heavily used to perform the visual tasks of pilotage, visual orientation, obstacle avoidance, and aircraft avoidance during terrain and above terrain flight with additional usage for ground clearance and landing point reference for the hover/taxi flight phase.

Table 5.

Demographics of utilization questionnaire respondents nonattack aircraft.

Aircraft type	Sex	n	Pilot/copilot flight hours		n	Crewman flight hours	
			Aircraft	Total		Aircraft	Total
CH-47	M	15	31,650	52,350	14	17,060	18,950
	F	0	0	0	0	0	0
OH-6	M	6	4,730	12,500	---	-----	-----
	F	0	0	0	0	0	0
OH-58A	M	4	680	2,330	---	-----	-----
	F	0	0	0	0	0	0
OH-58C	M	38	27,540	33,430	5	1,660	3,000
	F	1	120	1500	0	0	0
OH-58D	M	5	10,300	41,720	---	-----	-----
	F	0	0	0	0	0	0
UH-1	M	34	50,960	54,110	10	6,680	6,680
	F	0	0	0	0	0	0
UH-60	M	115	142,370	263,170	42	22,670	25,370
	F	2	575	675	0	0	0
Totals	M	217	268,280	459,610	71	48,070	54,000
	F	3	695	825	0	0	0

Note: All flight hour values are approximate.

• The overhead windscreens are used predominately for aircraft clearance, obstacle avoidance, and visual orientation in all flight phases.

• The chin bubbles are used predominately for obstacle avoidance, landing point clearance (reference), ground clearance, and visual orientation.

• The predominate problem identified with viewability through front and side windscreens is that of vision blockage due to cockpit interior design to include presence of vertical and horizontal supports.

• Typically, a third of all pilots find the size of overhead windscreens to be too small.

• Polycarbonate windscreens were cited as having greater optical quality problems than glass windscreens. However, regardless of composition, the most outstanding problem is that of surface scratches resulting from either the environment or cleaning methods. These scratches are major contributors to the second most frequently identified problem of haze.

• Sixty percent (154 of 257) of the pilots preferred a single continuous windscreen design with its inherent problem of distortion to one of a flat windscreen with its corresponding vision obstructions from support posts.

• The potential problem of an image (target) displacement due to prismatic deviation was identified as a nonissue, with 87 percent (224 of 257) reporting not having experienced prismatic deviation problems. Where this problem was reported, the overhead windscreen was the contributing port.

• The problem of flicker vertigo was identified as a non-issue, with 89 percent (229 of 257) reporting not experiencing this problem. Where reported, the windscreen at fault was the overhead windscreen and was a nuisance effect.

• Sixty-eight percent (175 of 257) of the responding pilots were not capable of reaching the designed pilot-eye-position in their respective aircraft; this was due largely to the fixed seat design in the OH-6 and OH-58A/C/D and various mechanical problems with the UH-60 seats.

• While rear-viewing capability was not cited as a major issue, 69 percent (177 of 257) did not express a need to view any external components that were not presently visible, 29 percent (75 of 257) did express the need to view other external components such as tail/rear area, the rotor area, etc. Suggestions to accomplish these tasks included mirrors, larger windows, and cameras.

Copilot/gunner (attack aircraft)

• Fifty percent (8 of 16) of the front-seated copilots/gunners rated the external viewability as "good" to "very good." None rated the external viewability as "poor" or "very poor."

• The front windscreens are used for all visual tasks in all flight phases.

• The side windscreens are used for all visual tasks in all flight phases, however with a noted decline in use for target engagement.

• The overhead windscreens are used predominately for the task of aircraft clearance in all flight phases.

• Vision blockages due to vertical and horizontal supports were the most cited problem with the front windscreen. The second most cited problem for the front windscreen was the glare from both internal and external light sources. Glare from interior lights was also the most cited problem with the side windscreens. The majority of copilots/gunners had "no problems" with the overhead windscreen.

• Scratches from the environment and cleaning methods with the resulting haze were the most prevalent problems in polycarbonate windscreens.

• Fifty percent (8 of 16) preferred a flat windscreen design to one of a single continuous curve.

• While overall the copilots/gunners were in favor of maintaining their current front seat position (9 of 16), 75 percent (3 of 4) of the AH-1 copilots/gunners expressed a preference to be in the aft seat as compared to 33 percent (4 of 12) for the AH-64.

• Fifty-six percent (9 of 16) had experienced additional external vision conflicts while using helmet-mounted devices. This was due largely to glare and physical contact with the support posts.

• Sixty-nine percent (11 of 16) reported being unable to adjust the seat of the aircraft to obtain an optimal pilot-eye-position. Even though the AH-1 front seat is not adjustable, the AH-64, which is adjustable, provided the most complaints.

• Flicker vertigo was not a problem for 88 percent (14 of 16) of the copilots/gunners. However, review of respondents' comments indicate it was the occurrence of flicker being reported rather than the onset of flicker vertigo.

• Twenty-five percent (4 of 16) reported experiencing prismatic deviation problems.

Crewmen

• Fifty-two percent (37 of 71) of the crewmen rated the external vision in their respective aircraft as "good" to "very good," with 44 percent (31 of 71) rating their aircraft "borderline" to "very poor."

• The rear ports/door windows/gunner windows are used for all visual tasks in all flight phases.

• The most cited problems with the rear ports/door windows/gunner windows were vision obstructions from support posts and add-on systems/equipment and their inadequate size.

• Scratches from the environment and cleaning methods were the most frequently cited problems with polycarbonate windscreens. Environmental scratches and cracks comprised the most frequently cited complaints about glass windscreens.

• Almost half, 48 percent (34 of 71), of crewmen reported experiencing additional problems while using helmet-mounted devices, citing contact with interior of aircraft and glare as the most frequent problems.

• The potential problem of an image (target) displacement due to prismatic deviation was identified as a nonissue, with 82 percent (58 of 71) reporting not having experienced prismatic deviation problems.

• While rear-viewing capability was not cited a major issue (75 percent (53 of 71) did not express a need to view any external components that are not presently visible), 15 percent (11 of 71) did express the need to view other external components such as tail/rear area, the rotor area, etc. Suggestions to accomplish these tasks included mirrors, larger windows, and cameras.

Specific aircraft findings

In addition to the generalized findings reported above, specific findings for each type of aircraft were noted. These findings are reported based on pilot and copilot/gunner data for attack aircraft and pilot/copilot and crewmen data for nonattack aircraft.

AH-1 (Pilot)

Overall external viewability

• Fifty-seven percent (4 of 7) rated the overall viewability of the aircraft as "good." Forty-three percent (3 of 7) rated it as "borderline" to "poor" citing obstructions by structural supports and internal design as the reason.

Tasks

• Front windscreens are used extensively for all visual tasks in all flight phases, however, to a lesser degree for the task of locating and maintaining landing point reference.

• Side windscreens are used for all visual tasks in all flight phases.

• Overhead windscreens are used primary for aircraft clearance, visual orientation, and object avoidance tasks.

Transparency/windscreen vision problems

• Obstructions from support posts and add-on equipment/systems were the most cited problems with the front windscreen. Other problems cited were the glare from interior lights and the inadequate size of the front windscreen.

Transparency/windscreen optical quality problems

• The most frequently cited problem with polycarbonate windscreens was scratches from cleaning. Complaints about haze and scratches from the environment were also numerous. These problems also were noted in glass windscreens.

Windscreen design preference

• Fifty-seven percent (4 of 7) preferred flat windscreens with support posts over one continuous curved canopy with its related distortion problems.

External component viewability

• Forty-three percent (3 of 7) expressed a need to check additional external components such as the tail area, landing gear, and engine area through the use of mirrors, cameras, or larger windows.

Prismatic deviation

• Only 14 percent (1 of 7) reported experiencing prismatic deviation problems with the windscreens.

Flicker vertigo

• Flicker vertigo was not a recurring problem for 86 percent (6 of 7). However, review of respondents' comments indicate it was the occurrence of flicker being reported rather than the onset of flicker vertigo.

Seat adjustment

• Fifty-seven percent (4 of 7) reported being able to adjust the seat of the aircraft to reach the optimal pilot-eye-position. However, 43 percent (3 of 7) are not able to achieve the pilot-eye-position due to conflicts with the Helmet Sight System(HSS) and the windscreens.

Seating preference

• Seventy-one percent (5 of 7) preferred the placing of the pilot in the aft seat with the copilot/gunner in the front seat.

NVG problems

• Forty-three percent (3 of 7) of the AH-1 pilots reported experiencing additional external vision problems when using NVGs. These problems included physical contact with the windscreens and glare.

AH-1 (Copilot/gunner)

Overall external viewability

• Twenty-five percent (1 of 4) rated the overall external viewability of the aircraft as "good." Seventy-five percent (3 of 4) rated the external viewability as "borderline," questioning the placement of support posts.

Tasks

• Front windscreens are used extensively for all visual tasks in all flight phases.

• The side windscreens are used extensively in all flight phases with a noted decline in the above terrain flight phase for the tasks of ground clearance and target engagement.

• The overhead windscreens are used predominately for obstacle avoidance and aircraft avoidance in all flight phases.

Transparency/windscreen vision problems

• All of the AH-1 copilots/gunners cited front and side windscreen problems with vision blockages due to vertical and horizontal supports and glare from interior lights in all phases of flight.

Transparency/windscreen optical quality problems

• Haze and scratches due to cleaning methods were reported as major problems with polycarbonate windscreens. Other noted complaints were scratches on polycarbonate windscreens from the environment and distortion.

Windscreen design preference

• AH-1 copilots/gunners were divided equally on windscreen design preference.

External component viewability

• Seventy-five percent (3 of 4) of the respondents indicted that there were external aircraft components which they would periodically like to view but were unable to with the current design. Most expressed the need to view the rear or tail area of the aircraft and suggested the use of mirrors to accomplish the task.

Prismatic deviation

• Seventy-five percent (3 of 4) reported not having experienced prismatic deviation problems.

Flicker vertigo

• Half (2 of 4) of the respondents noted a recurring problem with flicker vertigo. However, review of respondents' comments indicate it was the occurrence of flicker being reported rather than the onset of flicker vertigo.

Seat adjustment

• Fifty percent (2 of 4) reported being unable to obtain the optimal pilot-eye-position due to the fixed position of the front seat of the aircraft.

Seating preference

• Seventy-five percent (3 of 4) preferred the placement of the pilot in the front seat and the copilot/gunner in the aft seat.

Helmet-mounted system problems

• All (4 of 4) reported experiencing additional viewability problems when using helmet-mounted devices citing glare as the reason.

AH-64 (Pilot)

Overall external viewability

• Sixty percent (18 of 30) rated the overall external viewability of the aircraft as "good" or "very good." Six percent (2 of 30) rated it as "poor" or "very poor," with obstructions due to structural supports as the main problem.

Tasks

• Front windscreens are used extensively for almost all visual tasks in all flight phases except for ground clearance and locating/maintaining landing point reference.

• Side windscreens are used for all visual tasks in all flight phases.

• Overhead windscreens are used predominantly for the task of aircraft clearance and to a lesser degree for all other visual tasks during all flight phases.

Transparency/windscreen vision problems

• The most frequently cited problem was vision blockages due to vertical and horizontal supports. Obstructions due to basic internal design, such as placement of circuit breakers were also cited as a consistent problem.

• Glare from internal reflections was the second most frequently cited windscreen problem.

Transparency/windscreen optical quality problems

• Haze was reported as a major problem with polycarbonate windscreens. Complaints about scratches on polycarbonate windscreens resulting from cleaning were raised by 75 percent (23 of 30).

Windscreen design preference

• AH-64 pilots showed a slight preference for windscreen designs with flat windows (15 of 30) over one with curved canopy (12 of 30).

External component viewability

• Sixty percent (18 of 30) indicated that there were external aircraft components which they would periodically like to view but were unable to with current design. Some AH-64 pilots suggested the use of mirrors to view the tail or rear area of the aircraft. Others expressed the desire to view various other areas such as the nose box, wheels, guns, and refuel area.

Prismatic deviation

• Ten percent (3 of 30) reported experiencing prismatic deviation problems with windscreens.

Flicker vertigo

• Flicker vertigo was not a recurring problem for 83 percent (25 of 30) of the responding pilots. Thirteen percent (4 of 30) reported experiencing problems through the overhead windscreens. However, review of respondents' comments indicate it was the nuisance occurrence of flicker being reported rather than the onset of flicker vertigo.

Seat adjustment

• Eighty-three percent (25 of 30) reported having no difficulty in properly adjusting seat height to obtain optimum pilot-eye-position.

Seating preference

• AH-64 pilots reported only a small difference between a preference for the pilot being in the front seat (15 of 30) and the pilot being in the aft seat (13 of 30).

Helmet-mounted device problems

• Twenty percent (6 of 30) cited encountering restrictions of movement when using helmet-mounted devices (IHADSS).

AH-64 (Copilot/gunner)

Overall external viewability

• Fifty-eight percent (7 of 12) rated the overall external viewability as "good" or "very good." The remainder, forty-two percent (5 of 12), rated the viewability as "borderline," citing the presence of the large structural supports as the major reason.

Tasks

• The front windscreens are used extensively for all visual tasks in all flight phases with a noted decline in above terrain flight for the task of ground clearance.

• The side windscreens are used extensively for all visual tasks in all flight phases with a noted increase in usage for visual orientation.

• The overhead windscreens are used predominantly for aircraft clearance in all flight phases.

Transparency/windscreen vision problems

• The copilot/gunners reported fewer visual problems than the aft-seated pilot. However, vision blockages due to interior design and horizontal and vertical supports were frequently cited complaints.

Transparency/windscreen optical quality problems

• Windscreen problems, specifically scratches, were a dominating compliant.

Windscreen design preference

• Fifty percent (6 of 12) preferred a flat windscreen design with support posts over one continuous windscreen with related distortion problems (3 of 12).

External component viewability

• Fifty-eight percent (7 of 12) did not feel the need to view any external components that are not visible under present conditions. However, 25 percent (3 of 12) did express the need to view the engines.

Prismatic deviation

• Twenty-five percent (3 of 12) reported having experienced prismatic deviation problems.

Flicker vertigo

• None (0 of 12) of the AH-64 copilots/gunners reported having experiencing flicker vertigo.

Seat adjustment

• Only 25 percent (3 of 12) of the respondents reported the adjustment capability of the seat to be adequate.

Seating preference

• Sixty-six percent (8 of 12) preferred the seating of the pilot in the aft seat with the copilot/gunner in the front seat.

Helmet-mounted device problems

• Forty-two percent (5 of 12) reported having experienced problems due to contact of helmet-mounted systems (IHADSS) with add-on systems.

CH-47 (Pilot/copilot)

Overall external viewability

• Eighty-six percent (13 of 15) rated the overall external viewability of the aircraft as "good" or "very good." Thirteen percent (2 of 15) rated it as "borderline," citing the imbedded deicing system as a problem.

Tasks

• The front and side windscreens are used for all visual tasks in all flight phases, however to a significantly lesser degree for targeting tasks.

• Overhead windscreens are used primarily for the task of aircraft clearance in all flight phases.

• Chin bubbles are used predominately for the visual tasks of obstacle avoidance, ground clearance, landing point clearance (reference), and visual orientation.

Transparency/windscreen vision problems

• The most frequently reported problems with windscreens were glare from internal sources and vision blockage due to interior design and structural supports.

Transparency/windscreen optical quality problems

• The polycarbonate windscreens were a major source of complaints with the highest frequency of complaints being due to scratches and crazing.

Windscreen design preference

• CH-47 pilots did not have a clear consensus for preference between a flat windscreen design (7 of 15) and a continuous one-piece design (6 of 15).

External component viewability

• Thirteen percent (2 of 15) reported the need to view additional external components that are not presently viewable.

Prismatic deviation

• Thirteen percent (2 of 15) reported experiencing prismatic deviation problems.

Flicker vertigo

• Thirteen percent (2 of 15) reported experiencing problems with flicker vertigo. However, review of respondents' comments indicate it was the nuisance occurrence of flicker being reported rather than the onset of flicker vertigo.

Seat adjustment

• Eighty percent (12 of 15) reported the ability to achieve an optimal pilot-eye-position. The remaining 20 percent (3 of 15) cited problems with being able to see over the glare shield.

NVG problems

• Twenty-seven percent (4 of 15) reported experiencing problems with NVGs contacting the window posts.

CH-47 (Crewmen)

Overall external viewability

• Seventy-one percent (10 of 14) rated the overall viewability of the aircraft as "good." Twenty-eight percent (4 of 14) rated the total external vision as "borderline" to "very poor," citing the size of the windows and the placement of seats as contributing factors.

Tasks

• The rear ports/door windows/gunner windows are used in all flight phases for all visual tasks except pilotage (a noncrew task). However, there was a significant decline for targeting tasks.

• The bubble windows in the fuselage of the CH-47 are used for all visual tasks except pilotage (a noncrew task) and with a significant decline in usage for targeting tasks.

Transparency/windscreen vision problems

• The most significant complaint with the rear ports/door windows/gunner windows was the size of the windows being too small.

• Forty-three percent (6 of 14) noted the area of the bubble window in the fuselage as too small.

Transparency/windscreen optical quality problems

• Haze and scratches from cleaning were major problems with polycarbonate windscreens. Complaints about scratches from the environment and crazing on polycarbonate windscreens were cited by 57 percent (8 of 14).

External component viewability

• All (14 of 14) were satisfied with the current capability to view exterior components of the aircraft.

Prismatic deviation

• Fourteen percent (2 of 14) reported having experienced prismatic deviation problems.

NVG problems

• Eighty-six percent (12 of 14) reported experiencing problems with NVGs contacting the bubble window in the fuselage during use.

OH-6 (Pilot/copilot)

Overall external viewability

• One hundred percent (6 of 6) rated the overall external viewability of the OH-6 as "very good."

Tasks

• Front windscreens are used extensively for all visual tasks in all flight phases.

• "Side windscreens" are used for all visual tasks in all flight phases. Note: OH-6 aircraft are routinely flown without the doors.

• Overhead windscreens are used predominantly for the tasks of obstacle avoidance, aircraft clearance, visual orientation, and, to a lesser extent, targeting tasks.

• Chin bubbles are used predominantly for pilotage, obstacle avoidance, and visual orientation while performing terrain and above terrain flight and obstacle avoidance, landing point clearance (reference), and ground clearance in the hover/taxi flight phase.

Transparency/windscreen vision problems

• Only minimal problems with windscreens were reported. These included glare and distortion.

Transparency/windscreen vision problems

• Scratches from the environment (4 of 6) and cracks (3 of 6) were the most frequently cited problems with OH-6 windscreens.

Windscreen design preference

• All (6 of 6) of the OH-6 respondents indicated a preference for one continuous windscreen with related distortion problems over flat windscreens with support posts.

External component viewability

• Eighty-three percent (5 of 6) did not express the need to view additional external components that are not presently viewable.

Prismatic deviation

• None of the OH-6 pilots responding had experienced prismatic deviation due to the location of a window.

Flicker vertigo

• Flicker vertigo was not a recurring problem for any of the OH-6 pilots responding.

Seat adjustment

• Due to seats that are not adjustable, none of the OH-6 pilots were able to obtain pilot-eye-position.

NVG problems

• Sixty-six percent (4 of 6) reported viewability problems when using NVGs. One cited problem was the contact of the NVGs with the posts.

OH-58A (Pilot/copilot)

Overall external viewability

• Seventy-five percent (3 of 4) rated the overall viewability of the aircraft as "good" or "very good." Twenty-five percent (1 of 4) rated the viewability of the aircraft as "borderline."

Tasks

• The front windscreens are used extensively in terrain flight but to a significantly lesser degree for ground clearance and targeting tasks in above terrain and hover/taxi flight phases.

• Side windscreens are used predominantly for aircraft avoidance, pilotage, and obstacle avoidance in terrain and above terrain flight phases. Ground clearance and obstacle avoidance are the predominate tasks performed using the side windscreens in the hover/taxi flight phases.

• Overhead windscreens are used predominantly for obstacle avoidance in terrain and above terrain flight phases and aircraft clearance in the hover/taxi flight phase.

• Chin bubbles are used primary for the visual tasks of obstacle avoidance, landing point clearance (reference), ground clearance, and visual orientation for all flight phases.

Transparency/windscreen vision problems

• Obstructions from support post and interior design were the most frequently cited problems with the front windscreen in OH-58A aircraft.

• In all phases of flight, the most cited complaint with the side windscreens was the inadequate size of the windscreen.

• Fifty percent (2 of 4) noted problems with the inadequate size of the chin bubbles in the aircraft.

Transparency/windscreen optical quality problems

• All of the OH-58A pilots reported problems with scratches due to cleaning with polycarbonate windscreens; seventy-five percent (3 of 4) noted problems with distortion.

Windscreen design preference

• OH-58A pilots did not have a clear consensus for preference between flat windscreens with support posts (2 of 4) and one continuous windscreen with related distortion problems (2 of 4).

External component viewability

• Fifty percent (2 of 4) reported the need to view additional external components, usually the tail area.

Prismatic deviation

• None of the OH-58A pilots reported having experienced prismatic deviation problems.

Flicker vertigo

• Flicker vertigo was not a problem for any of the OH-58A pilots responding.

Seat adjustment

• Seventy-five percent (3 of 4) were not able to achieve optimal pilot-eye-position with the nonadjustable OH-58 aircraft seats.

NVG problems

• Seventy-five percent (3 of 4) reported having had additional problems with NVGs, usually contact with the side doors.

OH-58C (Pilot/copilot)

Overall external viewability

• Sixty-one percent (24 of 39) rated the aircraft as having overall viewability as "good" or "very good." Thirty-eight percent (15 of 39) rated the visual field as "borderline" to "poor," citing obstructions by various internal components.

Tasks

• The front windscreens are used extensively in terrain flight , with a marked decline for target engagement in the hover/taxi flight phase and ground clearance, target engagement, and landing point reference in above terrain flight.

• The side windscreens are used for all visual tasks in all flight phases and to a lesser degree for targeting tasks.

• The overhead windscreens are used predominantly for aircraft clearance in all flight phases.

• The chin bubbles are used predominantly for obstacle avoidance, landing point clearance (reference), and ground clearance in all flight phases.

Transparency/windscreen vision problems

• Obstructions from support post were the most cited problems with the front windscreen. Other significant problems cited were obstructions in interior design and add-on systems and glare from lights.

• The majority rated the overhead windscreen as inadequate in size.

Transparency/windscreen optical quality problems

• The most cited problems with polycarbonate windscreens were scratches from the environment, distortion, and haze. Complaints about scratches on polycarbonate windscreens resulting from cleaning were reported by 85 percent (33 of 39) of OH-58C pilots.

Windscreen design preference

• Ninety percent (35 of 39) preferred a single continuous curved windscreen design with its potential distortion problems over flat windows with support posts.

External component viewability

• Twenty-one percent (9 of 39) reported having the need to view external components such as the tail area and armament. Suggested methods included the use of mirrors, larger windows, rear windows, or another design.

Prismatic deviation

• Eighteen percent (7 of 39) reported having experienced prismatic deviation problems through the chin bubbles or the side windows.

Flicker vertigo

• Fifteen percent (6 of 39) reported having experienced flicker vertigo problems with the greenhouse (overhead) window. However, review of respondents' comments indicate it was the nuisance occurrence of flicker being reported rather than the onset of flicker vertigo.

Seat adjustment

• Ninety-five percent (37 of 39) were unable to reach optimal pilot-eye-position for their aircraft due to the OH-58C's nonadjustable seats.

NVG problems

• When using NVGs, 54 percent (21 of 39) reported having experienced problems with contact with the interior of the aircraft.

OH-58C (Crewmen)

Overall external viewability

• Sixty percent (3 of 5) rated the overall viewability of the aircraft as "borderline" to "very poor," citing the interference of too many add-on systems to the aircraft. Forty percent (2 of 5) rated the overall viewability as "good."

Tasks

• The rear ports/door windows/gunner windows and the front windscreens are used extensively for all visual tasks in all flight phases. However, there is a significant decline in usage for the tasks of target engagement and checking the aircraft for mechanical and safety problems.

Transparency/windscreen vision problems

• Vision blockages due to interior design was the most frequently cited problem, with values as 100 percent for some flight modes.

• The most frequently cited problems with the rear ports/door windows/gunner windows were glare from interior lights and obstructions from interior design. Obstructions from vertical and horizontal supports and the limited size of the view ports were also cited as consistent problems.

Transparency/windscreen optical quality problems

• Haze and scratches from cleaning were reported as major problems with polycarbonate windscreens. Complaints about scratches from the environment on polycarbonate windscreens were raised to 80 percent (4 of 5) of the respondents.

External component viewability

• Forty percent (2 of 5) expressed the need to view external components of the aircraft that are not presently visible. Suggestions were made to utilize mirrors, larger windows or new windows to view the skids.

Prismatic deviation

• Twenty percent (1 of 5) had experienced prismatic deviation problems.

NVG problems

• Eighty percent (4 of 5) reported movement limitations when using NVGs in the aircraft. The majority of these problems were related to contact from add-on systems.

OH-58D (Pilot/copilot)

Overall external viewability

• Eighty percent (4 of 5) rated the overall external viewability as "good" or "very good." Twenty percent (1 of 5) rated the viewability as "borderline," citing the position of the PDU (Pilot's Display Unit) system as the reason.

Tasks

• The front windscreens are used for all visual tasks in all flight phases but to the highest extent in the hover/taxi flight phase.

• The side windscreens are used predominantly for obstacle avoidance, reconnaissance, visual orientation, and aircraft avoidance in all flight phases.

• The overhead windscreens are utilized to a lesser degree than other OH-58D windscreens; however, the primary tasks, when used, are for aircraft clearance and visual orientation.

• The chin bubbles are used predominantly for the visual tasks of obstacle avoidance, ground clearance, and visual orientation in all flight phases.

Transparency/windscreen vision problems

• Blockage due to interior design of aircraft was the most commonly reported problem with viewing out of chin bubbles.

Transparency/windscreen optical quality problems

• Distortion in the front windscreens due to the imbedded moisture removal systems and blockage due to vertical and horizontal supports were the most frequently experienced viewability problems.

• Scratches due to cleaning methods and the environment were reported as a major problem.

Windscreen design preference

• All (5 of 5) of the OH-58D crewmen respondents indicated a preference for one continuous windscreen with related distortion problems over flat windscreens with support posts.

External component viewability

• Eighty percent (4 of 5) did not feel the need to view additional external components that are not presently viewable.

Prismatic deviation

• None of the OH-58D pilots responding had experienced prismatic deviation due to the location of a window.

Flicker vertigo

• None of the OH-58D pilots responding had experienced flicker vertigo problems due to the location of a window.

Seat adjustment

• Eighty percent (4 of 5) were unable to obtain an optimal pilot-eye-position. Note: The OH-58D does not have adjustable seats.

NVG problems

• Eighty percent (4 of 5) have experienced viewability problems when using NVGs.

UH-1 (Pilot/copilot)

Overall external viewability

• Ninety-four percent (32 of 34) rated the overall viewability of the aircraft as "good" or "very good." Six percent (2 of 34) rated the viewability as "borderline" to "poor," giving no qualifying statement.

Tasks

• The front windscreens are used predominantly for the visual tasks of pilotage, obstacle avoidance, aircraft avoidance, and visual orientation for all flight phases.

• The side windscreens are used predominantly for the visual tasks of obstacle avoidance, aircraft avoidance, and visual orientation in all flight phases. However, there is a noted increase in the visual task of pilotage in terrain and above terrain flight.

• The overhead windscreens are used predominantly for aircraft clearance in all flight phases.

• The chin bubbles are used predominantly to perform the visual tasks of obstacle avoidance, landing point clearance (reference), and ground clearance for terrain and hover/taxi flight phases, additionally, the task of aircraft avoidance for above terrain flight.

Transparency/windscreen vision problems

• The majority experienced no problems with the windscreens in all phases of flight in the aircraft.

Transparency/windscreen optical quality problems

• UH-1 pilots listed scratches from cleaning as the most frequent problem with polycarbonate windscreens. Other problems cited were scratches from the environment and crazing. The most cited problem with glass windscreens was scratches from the environment.

Windscreen design preference

• Fifty-six percent (19 of 34) preferred a single continuous curved windscreen design with inherent distortion problems over preferred flat windows with support posts [29 percent (10 of 34)] .

External component viewability

• Twenty-one percent (7 of 34) express the need to view the tail area of the aircraft.

Prismatic deviation

• Three percent (1 of 34) reported having experienced prismatic deviation problems.

Flicker vertigo

• Nine percent (3 of 34) of the UH-1 pilots reported flicker vertigo as a problem. However, review of respondents' comments indicate it was the nuisance occurrence of flicker being reported rather than the onset of flicker vertigo.

Seat adjustment

• Eighteen percent (6 of 34) reported being un able to adjust their seat to optimal pilot-eye-position.

NVG problems

• Thirty-two percent (11 of 34) reported having experienced problems with external vision when using NVGs.

UH-1 (Crewmen)

Overall external viewability

• Ninety percent (9 of 10) of rated the overall visual field of the aircraft as "good" to "very good."

Tasks

• The rear ports/door windows/gunner windows and the front windscreens are used for all visual tasks in all flight phases.

Transparency/windscreen vision problems

• Few problems were reported. The most frequently cited was vision blockage due to interior design.

Transparency/windscreen optical quality problems

• Scratches from cleaning was the most cited problem with polycarbonate windscreens. Problems with crazing and scratches from the environment also were cited.

External component viewability

• Ten percent (1 of 10) reported the need to visually check any external component that are not presently visible.

Prismatic deviation

• There were no reports (0 of 10) of prismatic deviation problems.

NVG problems

• Fifty percent (5 of 10) reported experiencing problems when using NVGs. Contact with windows and glare from interior light when the cargo doors were closed were reasons given for some of the problems.

UH-60 (Pilot/copilot)

Overall external viewability

• Thirty-three percent (39 of 117) rated the overall viewability as "good" or "very good." Sixty-seven percent (78 of 117) rated the overall viewability of the aircraft from "borderline" to "very poor," citing obstructions due to structural supports and interior design as the main problems.

Tasks

• The front and side windscreens are used extensively for all visual tasks in all flight phases.

• The overhead windscreens are used predominantly for the visual task of aircraft clearance in terrain and hover/taxi flight phases and to a lesser degree in above terrain flight.

• The chin bubbles are used predominantly for the visual tasks of obstacle avoidance, landing point clearance (reference), and ground clearance in terrain and hover/taxi flight phases and to a lesser extent in above terrain flight.

Transparency/windscreen vision problems

• Most problems with the front and side windscreens were attributed to vision blockages due to support posts and interior design in UH-60 aircraft. The majority of pilots expressed no problems with the overhead windscreens. From 42 to 57 percent, depending on mode of flight, identified the chin bubbles as being inadequate in size (too small).

Transparency/windscreen optical quality problems

• UH-60 pilots cited most often problems with scratches from the environment. Other noted problems were haze, distortion, and additional scratches from cleaning. The most cited problem with glass windscreens was cracking with other frequent problems being chipping, scratches from the environment and cleaning.

Windscreen design preference

• Fifty-eight percent (56 of 117) preferred a single continuous windscreen design with its inherent distortion problems to the flat windscreen design with support posts [35 percent (41 of 117)].

External component viewability

• Twenty-nine percent (34 of 117) expressed the need to view the tail area, sling loads, and landing gear. Suggested methods to achieve this included the use of mirrors, larger bubbles, and cameras.

Prismatic deviation

• Eight percent (9 of 117) reported having experienced prismatic deviation problems with the windscreens.

Flicker vertigo

• Seven percent (8 of 117) of UH-60 pilots reported flicker vertigo as a problem. However, review of respondents' comments indicate it was the nuisance occurrence of flicker being reported rather than the onset of flicker vertigo.

Seat adjustment

• Ninety-three percent (109 of 117) reported being unable to adjust the seat in the UH-60 to achieve the designed optimal pilot-eye-position. Difficulty with the seat adjustment mechanism, poor seat positioning, and too many obstructions were listed as contributing factors.

NVG problems

• Thirty-six percent (42 of 117) reported having experienced additional problems using NVGs, citing contact with the interior of the cockpit.

UH-60 (Crewman)

Overall external viewability

• Fifty-eight percent (24 of 42) rated the overall viewability of the aircraft as "borderline" to "very poor," citing the justification as obstructions from support posts and interior components. Thirty-eight (16 of 42) rated the overall viewability as "good."

Tasks

• The rear ports/door windows/gunner windows and the front windscreens are used for all visual tasks in all flight phases.

Transparency/windscreen vision problems

• Obstructions from support post and add-on systems/equipment were the most frequently cited problems with the rear ports/door windows/gunner windows. The size of the view ports, obstructions due to interior design, and distortion due to curvature also were identified as additional problems.

Transparency/windscreen optical quality problems

• Problems cited most frequently for polycarbonate windscreens included haze and scratches from the environment and cleaning. The most cited problem for glass windscreens was scratches from the environment.

External component viewability

• Twenty-one percent (9 of 42) expressed the need to visually check external aircraft components that are not presently visible. These components include the tail, landing gear, and sling loads.

Prismatic deviation

• Seventeen percent (4 of 24) reported having experienced prismatic deviation problems with the green house windows and cockpit doors windows.

NVG problems

• Thirty-three percent (14 of 42) reported vision problems when using NVGs. Problems cited include interior glare and contact with windows.

Visual ports as a factor in U.S. Army rotary-wing accidents

The size and placement of visual ports in aircraft and the resulting external vision are important factors in safety and the efficient operation in such a visually intensive task as rotary-wing flight.

To investigate the role of visual ports as a factor in U.S. Army rotary-wing accidents, the U.S. Army Safety Center, Fort Rucker, Alabama, was asked to perform a search of its accident data base for the occurrence of Class A-C accidents for the period of FY80-18MAY95. The search was implemented using the following keywords: field-of-view, visibility, visual field, external vision, visual limitation, and blind spot.

For the search parameters cited above, 14 accidents were identified. Of these, only three accidents had external vision listed as a "present and contributing factor." Two involved UH-60 aircraft; one involved an AH-64 aircraft. Air frame restrictions and blind spots were the descriptive terms used to define the contributing factors in these accidents. In the other accidents, reduced visibility resulting in almost all cases from glare and rain/fog was listed as a factor. Table 6 classifies all identified accidents by aircraft type and accident class. A synopsis of each accident is given in Appendix G.

Table 6.

Accidents by aircraft type.

Accident class	Aircraft type							
	AH-1	AH-64	CH-47	OH-6	OH-58	TH-67	UH-1	UH-60
A	0	0	0	0	0	0	0	2*
B	0	0	0	0	1	0	0	0
C	2	1*	0	0	7	0	1	1
Totals	2	1	0	0	8	0	1	3

* Accidents where external vision was cited as a present and contributing factor.

Discussion and summary

This report documents the location and extent of visual ports in the nine fielded U.S. Army rotary-wing aircraft models. This was accomplished through a compilation of visual plots from various U.S. Army and manufacturer sources and special 360-degree photographs representing available visual fields from a typical pilot-eye position. Additionally, 344 pilots and crewmen were surveyed as to their opinion on use, problems, and design preferences of windows/windscreens for their respective aircraft. Finally, a review of accident data was conducted to identify incidents where impaired external vision was cited as a contributing factor.

Visual plots and photographic documentation

When the representative visual fields as depicted in the 360-degree photographs (left seat for nonattack, rear seat for attack) are compared to the visual plots reproduced from the respective specifications, an assessment of external viewability and potential problems can be performed. The effect of tandem seating on viewability is obvious for the AH-1 and AH-64 (Figures 20-21 and A-1, A-2). First, there is the symmetry in the available visual field, providing

equal viewing capability out of both sides of the aircraft. Second, the presence of vision blockages due to support struts is very prominent, a major source of complaints documented by the questionnaire data.

For the nonattack aircraft with side-by-seating, photographs and vision plots illustrate the reduced side vision available on the alternate side. This is persuasive evidence for the need of increased crew coordination for this seating design. As with the attack aircraft, the presence of blockages from support struts is obvious.

Questionnaire data rated the OH-6 and the UH-60 as the best and worst for overall viewability, respectively. These ratings are borne out by the photographs and vision plots. Due to its small size, the OH-6 (Figures 4 and A-4) has the narrowest support struts and increased overhead and alternate side visual fields. In contrast, the UH-60 (Figures 10 and A-10) has extremely limited vertical and alternate side visual fields.

Utilization questionnaires

Questionnaire data were grouped as pilot/copilot, copilot/gunner, and crewman. Data provided insight into how pilots and crewmen use the visual ports, problems encountered during performance of pilotage and other required tasks, and user opinion on possible design changes.

Pilots/copilots

With the exception of the two U.S. Army attack aircraft (AH-1 and AH-64), a side-by-side seating configuration is used. As a rule, the front seat aviators share tasks, and the assignation of "pilot" and "copilot" is not based on experience or ability. For this reason, the data for designated pilots and copilots for nonattack aircraft were grouped and analyzed together.

Pilots/copilots were requested to indicate which of nine identified tasks were performed through the various visual ports for the identified flight phases of terrain flight, above terrain flight, and hover/taxi. Data showed predictable usage trends. In general, front and side windscreens are used heavily for all tasks for all flight phases. Overhead windscreens are used primarily for aircraft clearance and obstacle avoidance. Chin bubbles are used predominately for ground clearance, visual orientation, landing point clearance, and obstacle avoidance. These conclusions held true for all aircraft types.

By far, the greatest reported problem with current aircraft/windscreen designs is vision blockages due to interior design, vertical/horizontal support struts, and add-on systems. Vision blockages by one or more of these reasons was the most frequently cited problem by every aircraft, for every flight phase, for every window (except overhead). CH-47 and UH-60 pilots/copilots complained of the instrument panel being too high; AH-1 pilots complained that they often lose other aircraft in width of supports; AH-64 pilots complained that the circuit

breaker blocks on the left side obstruct vision; OH-58C pilots/copilots complained that the glare shield is too large. The second most frequently cited problem was glare from interior light sources.

US. Army windscreens are primarily of acrylic composition. Glass also is used. Acrylic windscreens were cited as having the greater number of problems. The most prevalent problem was scratches, due either to environmental exposure or cleaning methods, and the resulting haze. In March 1995, USAARL surveyed the optical transmittance characteristics of windscreens on aircraft in the field (Wentworth, et al., 1995). One conclusion of this survey was the finding that a significant percent decrease in luminous transmittance existed between new samples of a windscreen and those which had been fielded for even short periods of time. The reason provided for this decrease was the high level of haze resulting from the highly abraded condition of the fielded windscreens.

Across all aircraft, 55 percent of the pilots/copilots rated the overall external viewability of their respective aircraft as "good" or "very good." This contrasts with only a 13 percent rating of "poor" or "very poor." The highest ratings were for the OH-6, UH-1, and CH-47 with 100, 94, and 86 percent ratings for "good" or "very good." The lowest rated aircraft was the UH-60 with only a 33 percent rating for "good" or "very good" and a 23 percent rating for "poor" or "very poor." UH-60 pilots/copilots cited instrument panels, glare shields, vertical/horizontal supports, and too small front windows as reasons for the low rating.

When asked about the need to view aircraft components which currently cannot be seen, 29 percent indicated a desire to be able to view rear and under areas of their aircraft, e.g., tail rotor, engine nacelles, wheels, nose gear boxes, etc. Suggestions of how to overcome this deficiency included larger windows and the use of mirrors or cameras.

Overall, pilots/copilots preferred a one piece continuous windscreen design over that of one with flat windows in a ratio of two to one. However, this trend was reversed for the two attack aircraft, AH-1 and AH-64, and for the CH-47. A possible explanation for the trend reversal for the attack aircraft is the high frequency of complaints regarding the vision blockages by vertical/horizontal supports from pilots/copilots of these aircraft.

Prismatic deviation with its resulting shift in images was cited as a nonproblem by 87 percent of the pilots/copilots surveyed. The highest percent frequency was 14 percent for the AH-1 and comments provided seemed to imply the pilot/copilot was describing a distortion problem rather than one due to prismatic deviation.

Flicker vertigo also was identified as a nonproblem with only 9 percent of the pilots/copilots reporting it. When cited, it was associated with an overhead window and was considered a nuisance effect rather than the actual presence of the condition of flicker vertigo.

Sixty-eight percent of the pilots/copilots reported being unable to achieve an optimal pilot-eye-position. Aircraft for which this was a significant problem was the OH-6, OH-58A/C/D, and UH-60. The lack of adjustable seats in the OH-6 and OH-58 is the most likely explanation for these aircraft. UH-60 pilots/copilots complained of seats which are to adjust or jam and having too many vision obstructions. The AH-64 and CH-47 were reported as providing the highest probability of achieving an optimal eye-position.

When AH-1 and AH-64 pilots were surveyed as to seating preference in these tandem seated aircraft, AH-1 pilots preferred the current rear seat in a ratio of greater than 2 to 1. AH-64 pilots were almost even in preference, showing only a slight preference for the copilot/gunner front seat position.

Additional viewability problems with helmet-mounted devices such as ANVIS were reported primarily by OH-58A/C/D pilots/copilots. Physical contact with windscreens and add-on systems was the most frequently cited reason.

Copilots/gunners (AH-1 and AH-64 attack aircraft)

The AH-1 and AH-64 comprise the category of attack aircraft in the Army. Both of these aircraft use tandem seating in which the copilot/gunner sits in the front seat and the pilot sits in the aft seat directly behind the copilot/gunner, but slightly elevated. The copilot/gunner's primary function is target acquisition and engagement. However, pilotage tasks also are performed to a significant extent.

The tandem seating design of the attack aircraft provides greatly improved side viewability. However, due to the placement of imaging systems (PNVS and TADS) on the nose, over-the-nose viewability of the AH-64 for the copilot/gunner is compromised. This problem is alleviated somewhat during flight since a nose down attitude is used. Conversely, the problem is accentuated during approaches and landings, when the nose is flared up. In spite of these problems, 58 percent of AH-64 copilots/gunners rated the overall external viewability as "good" or "very good" compared to only 25 percent for the AH-1.

When asked whether they preferred the current gunner in front seat/pilot in aft seat to a reverse configuration, AH-64 copilots/gunners preferred the current seating arrangement 2 to 1. However, AH-1 copilots/gunners preferred the opposite seating configuration of copilot/gunner in the aft seat by 3 to 1.

The vision problems most frequently reported by attack aircraft copilots/gunners were vision blockages by support rails and glare from interior lights. Both attack aircraft use relatively flat canopy designs. This approach increases the presence of glare sources resulting from reflections. While reported for both attack aircraft, the frequency of this problem was often several times higher for the AH-1 than for the AH-64. This is most likely the result of the angles

of the windows and the placement and orientation of interior indicator lights. The problem of vision blockages also was cited frequently for the AH-1.

The windscreen material of both attack aircraft suffers from a high incidence of scratches and the resulting haze. These problems are slightly greater in the AH-1. Distortion and crazing also were cited as frequent problems.

Seventy-five percent of AH-1 copilots/gunners surveyed expressed a desire to be able to see areas to the rear of the aircraft which cannot currently be viewed. Suggestions to solve this problem included use of mirrors.

Even though the front seat of the AH-1 is not adjustable, 50 percent of the copilots/gunners reported being able to achieve an optimal pilot-eye-position. However, citing instrument panels and glare shields as confounding factors, three-fourths of AH-64 copilots/gunners reported being to achieve the optimal vertical position.

All AH-1 copilots/gunners reported problems when using NVGs/ANVIS in the front seat. Glare was the most frequent complaint.

Crewmen

Crewmen generally use the aircraft visual ports perform tasks related to the primary function of their aircraft. In addition to these tasks, crewmen are expected to assist pilots in such pilotage tasks as obstacle avoidance, aircraft clearance, target detection, etc. The crewman also serves as additional eyes for the pilots in checking the aircraft for mechanical and safety problems during flight. For the four aircraft (CH-47, OH-58C, UH-1, and UH-60) for which crewmen questionnaires were distributed, the data indicate that crewmen heavily utilize all available ports to perform all of these tasks during all flight modes, with lesser usage only for tasks of pilotage and targeting which are primarily pilot/copilot tasks.

When asked to identify problems which affect the performance of the required tasks, crewman vision blockages due to vertical and horizontal structural support rails and add-on equipment and systems were frequently cited. CH-47 crewmen emphasized problems with the bubble windows which are unique to the CH-47. Several crewmen rated these windows as too small. A major complaint was the use of NVGs with these windows. Eighty-six percent of the CH-47 crewmen surveyed reported having problems when attempting to view through the bubble windows when wearing NVGs. This problem also was reported by OH-58C and UH-1 crewmen, who complained of restricted head movement and continuous contact with windows.

Overall, 53 percent of the crewmen rated the external viewability of their respected aircraft as "good" or "very good." The UH-1 was the highest rated aircraft with 90 percent of the crewmen surveyed giving a "good" or "very good" rating. The CH-47 had the second best

crewmen rating. Crewmen of the OH-58C complained about vision restrictions resulting from add-on systems.

Consistently, polycarbonate windscreens present more problems than glass windscreens. When asked to report problems experienced with the windscreen material itself, crewmen overwhelmingly cited scratches and resulting haze and glare as the most outstanding problem. In OH-58C aircraft, which has only polycarbonate windscreens, 80 percent of those surveyed reported problems with scratches.

External vision related accidents

A search of the accident data base was performed by the U.S. Army Safety Center, Fort Rucker, Alabama. The search covered the period of FY80-18May95 and used the following keywords: field-of-view, visibility, visual field, external vision, visual limitation, and blind spot. A total of 14 accidents were identified. Of these, only three had external vision listed as a "present and contributing factor." Two UH-60 and one AH-64 aircraft were involved. In all three accidents air frame restrictions and blind spots caused by structural supports were cited. The reference to frame restrictions relates to the reduced UH-60 visual fields documented in the photographs and vision plots and is supported by the lowest rating for overall viewability of all aircraft given by pilots/copilots in the questionnaires. In addition, the second reference to blind spots also is supported by the questionnaire data; the most frequently cited problem with current aircraft visual port designs was vision blockages due to vertical/horizontal supports and add on systems.

Recommendations

The results of this investigation cannot be expected to impact fielded aircraft structural designs. Therefore, current aviators and crewmen can expect no improvement over current availability of external viewability by structural design changes. However, there is strong evidence to support the attention which should be given to size and placement of structural supports in future designs.

A problem which can and must be addressed for current aircraft is the degradation in optical quality which rapidly occurs in windscreens and severely decreases flight performance. Scratches and the resulting haze and glare are major, wide-spread problems. Methods to protect windscreens from scratches due to the flight environment should be investigated in a timely manner. Also, there is evidence that these windscreens are being scratched by currently employed cleaning methods.

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Appendix A.

Rotary-wing aircraft vision plots

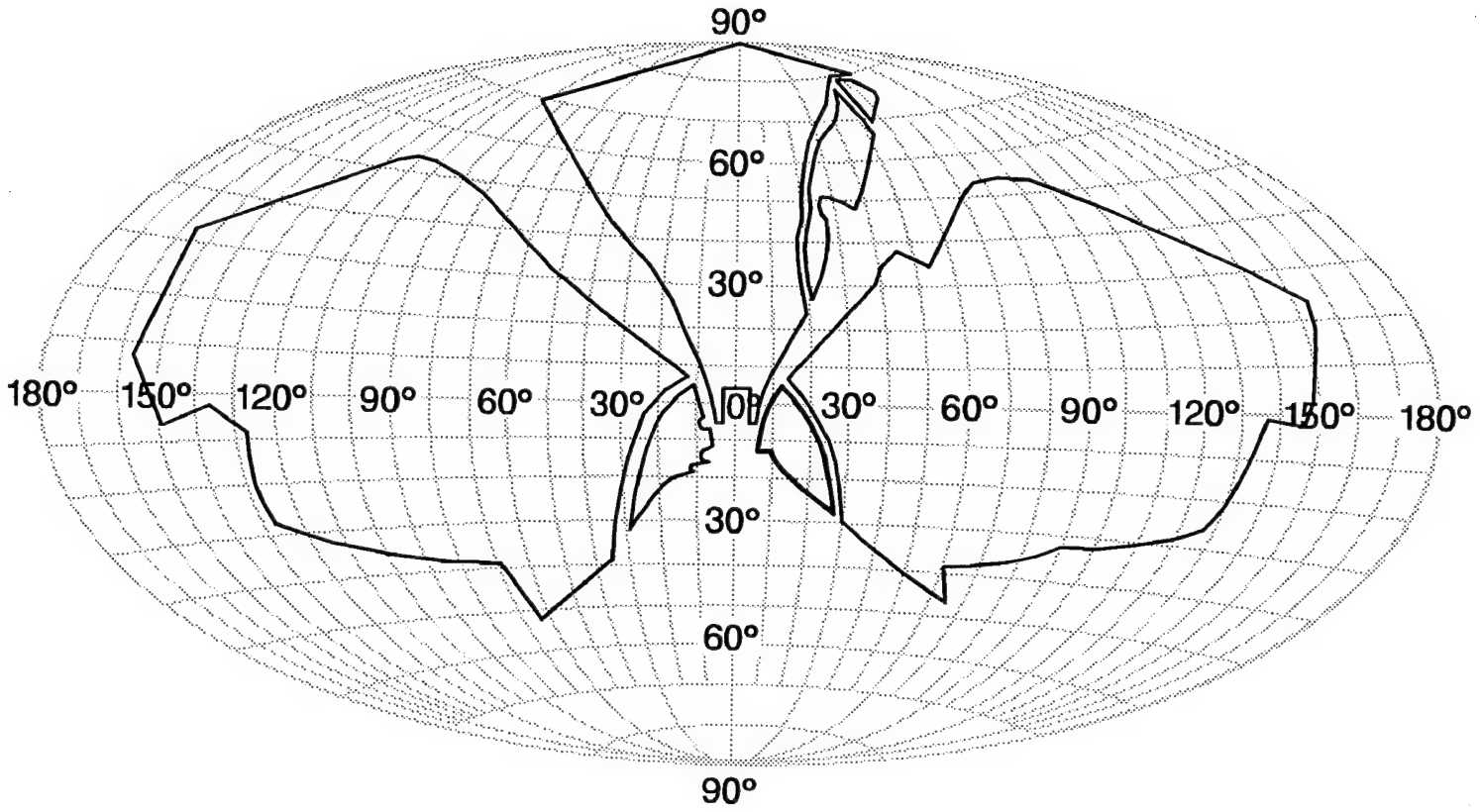

Figure A-1. Vision plot for AH-1S/F Cobra.

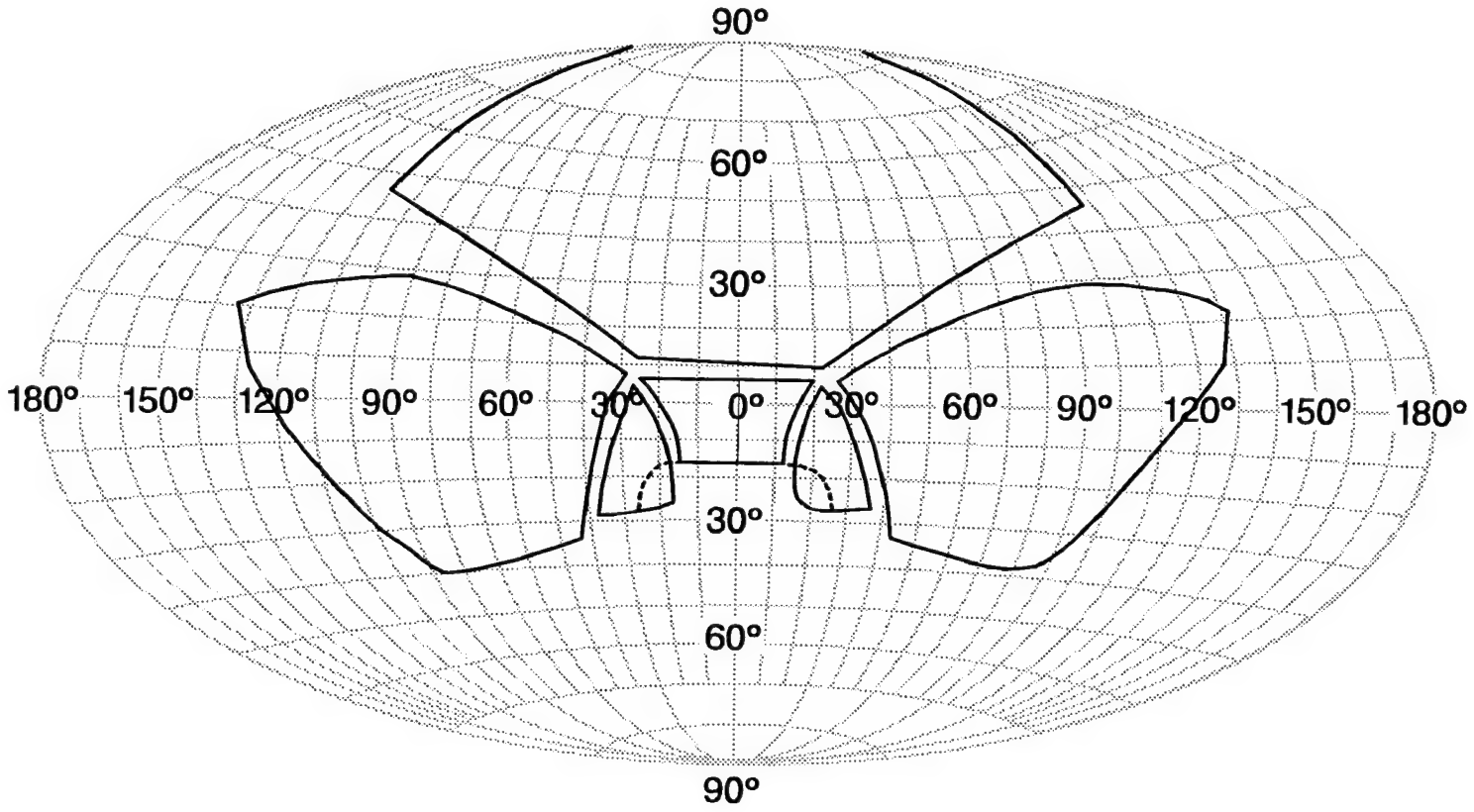

Figure A-2. Vision plot for AH-64 Apache.

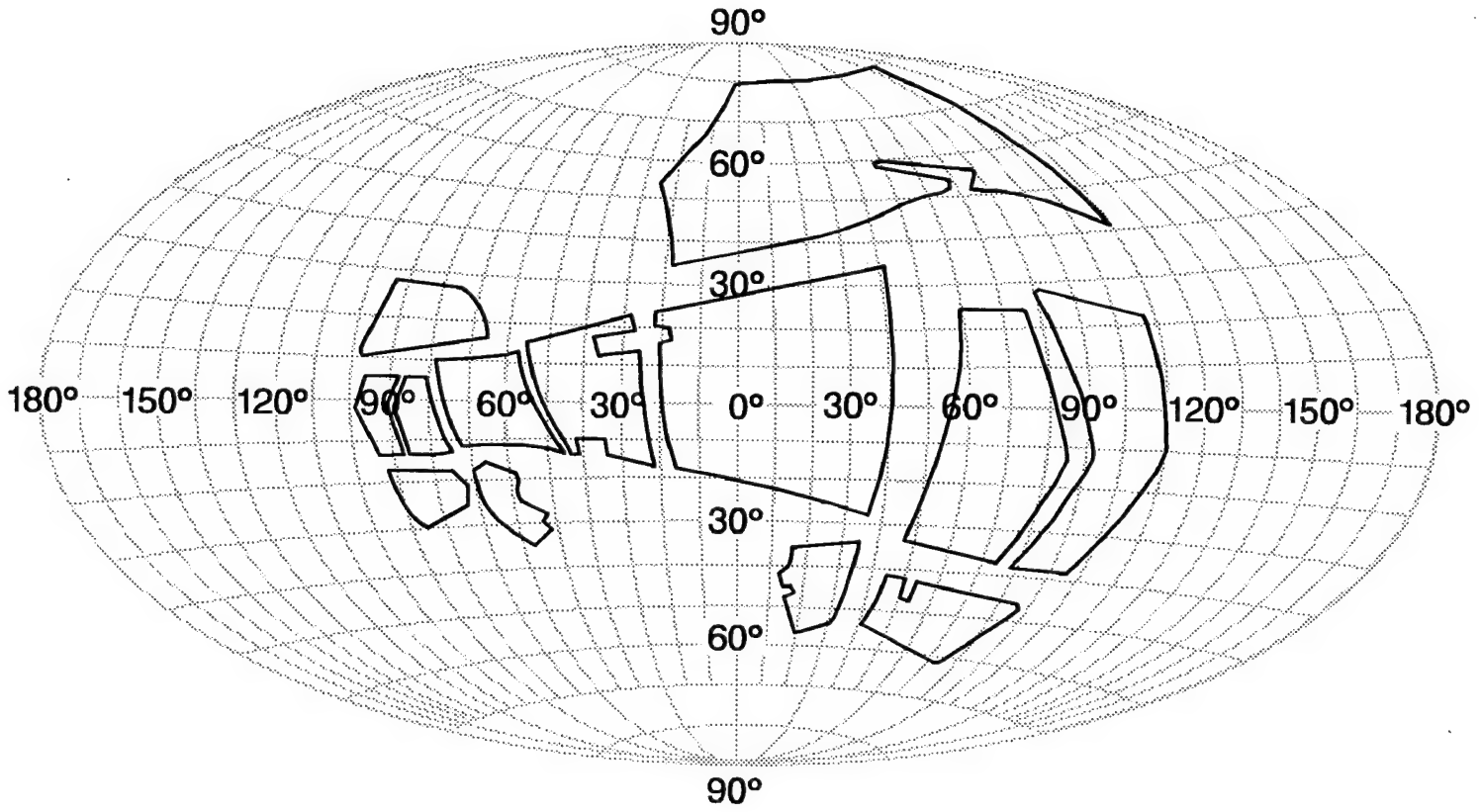

Figure A-3. Vision plot for CH-47D Chinook.

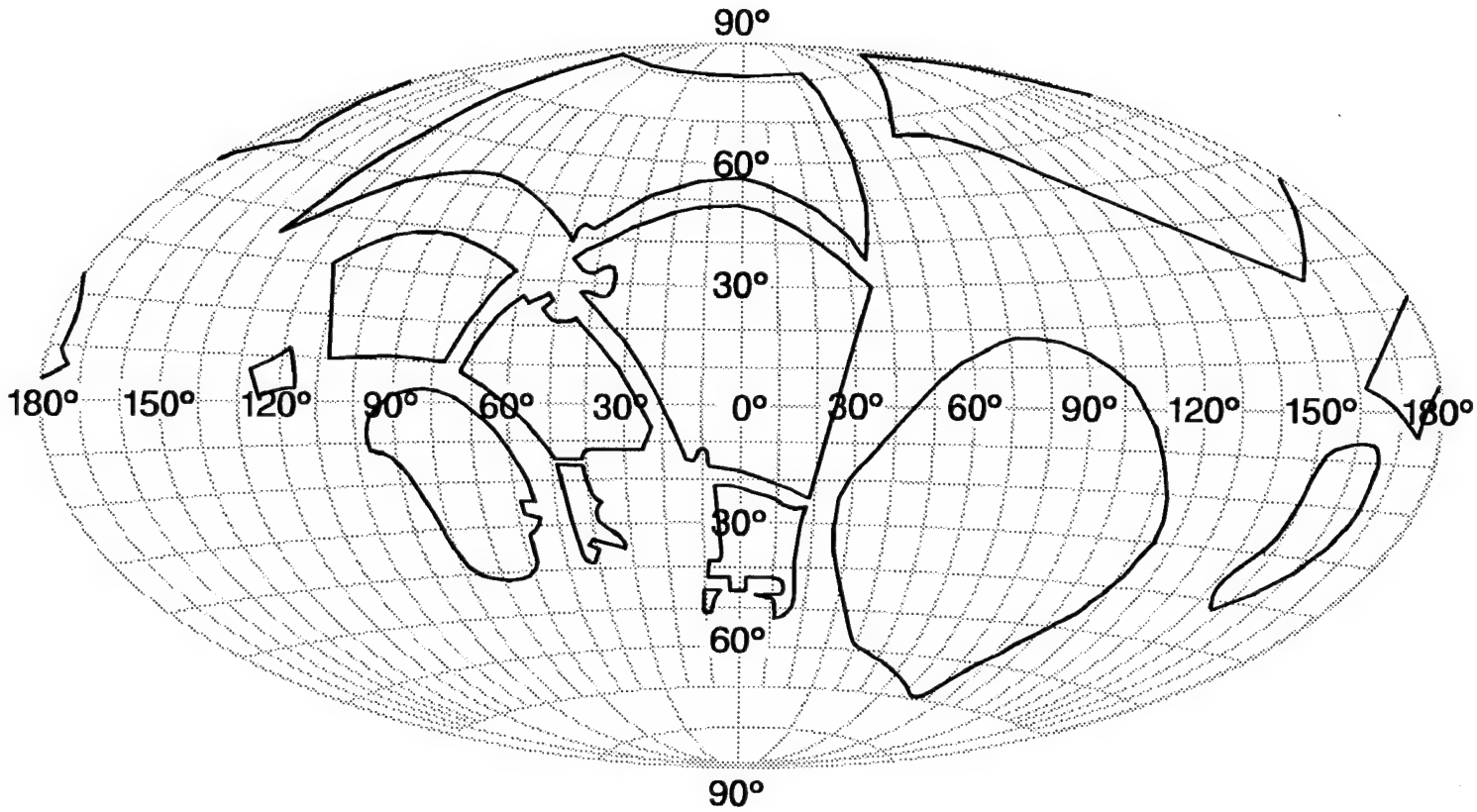

Figure A-4. Vision plot for OH-6 Caysue.

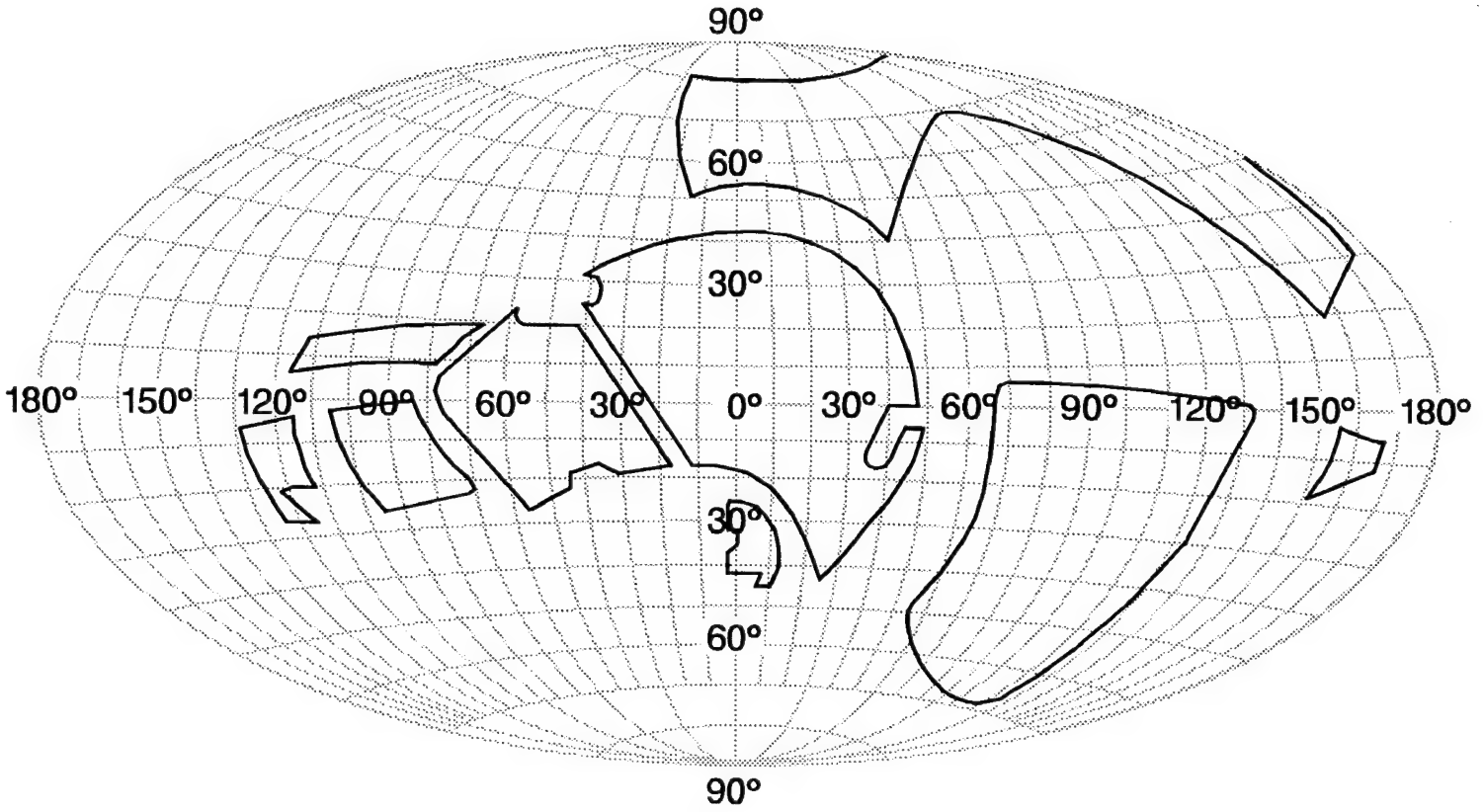

Figure A-5. Vision plot for OH-58A Kiowa.

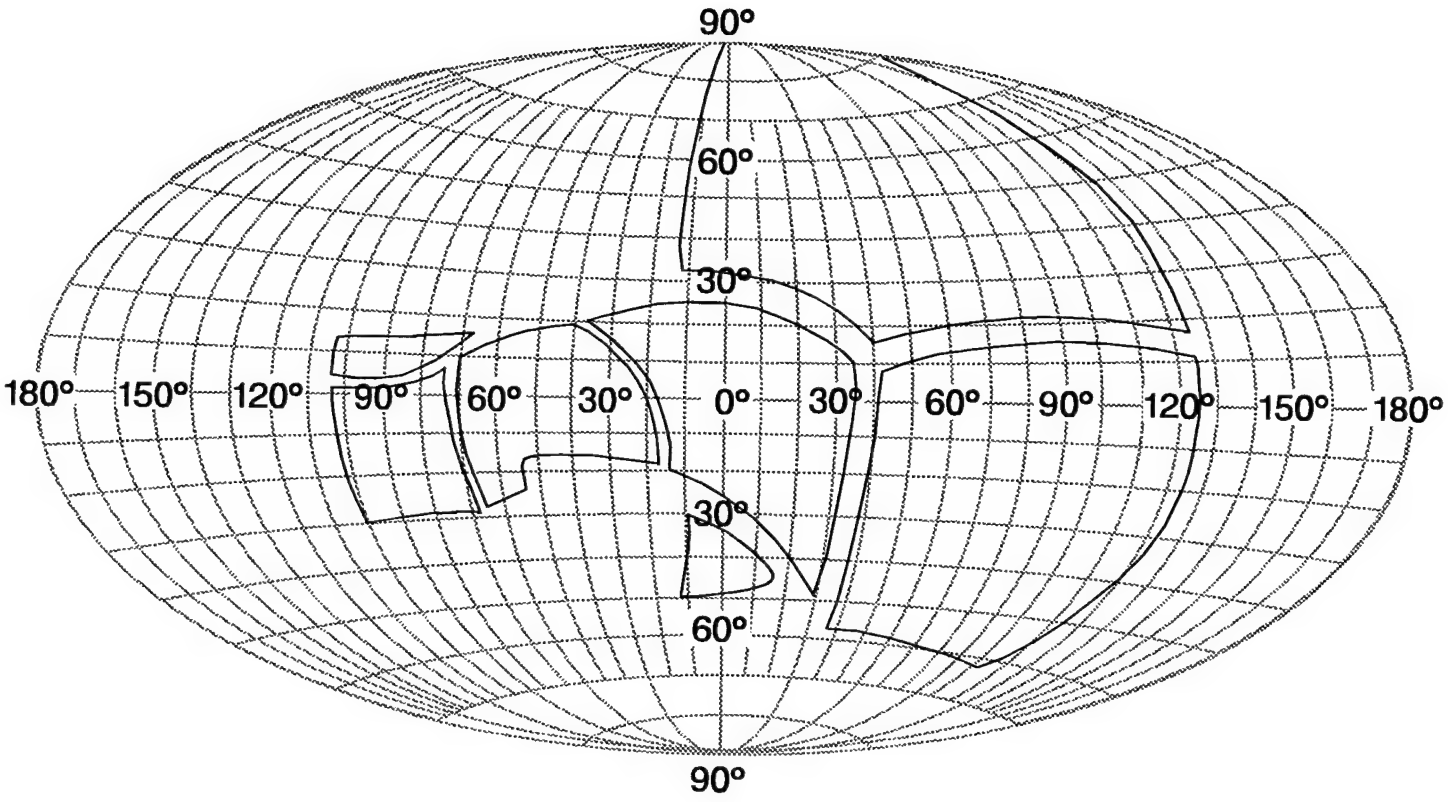

Figure A-6. Vision plot for OH-58C Kiowa (flat panel).

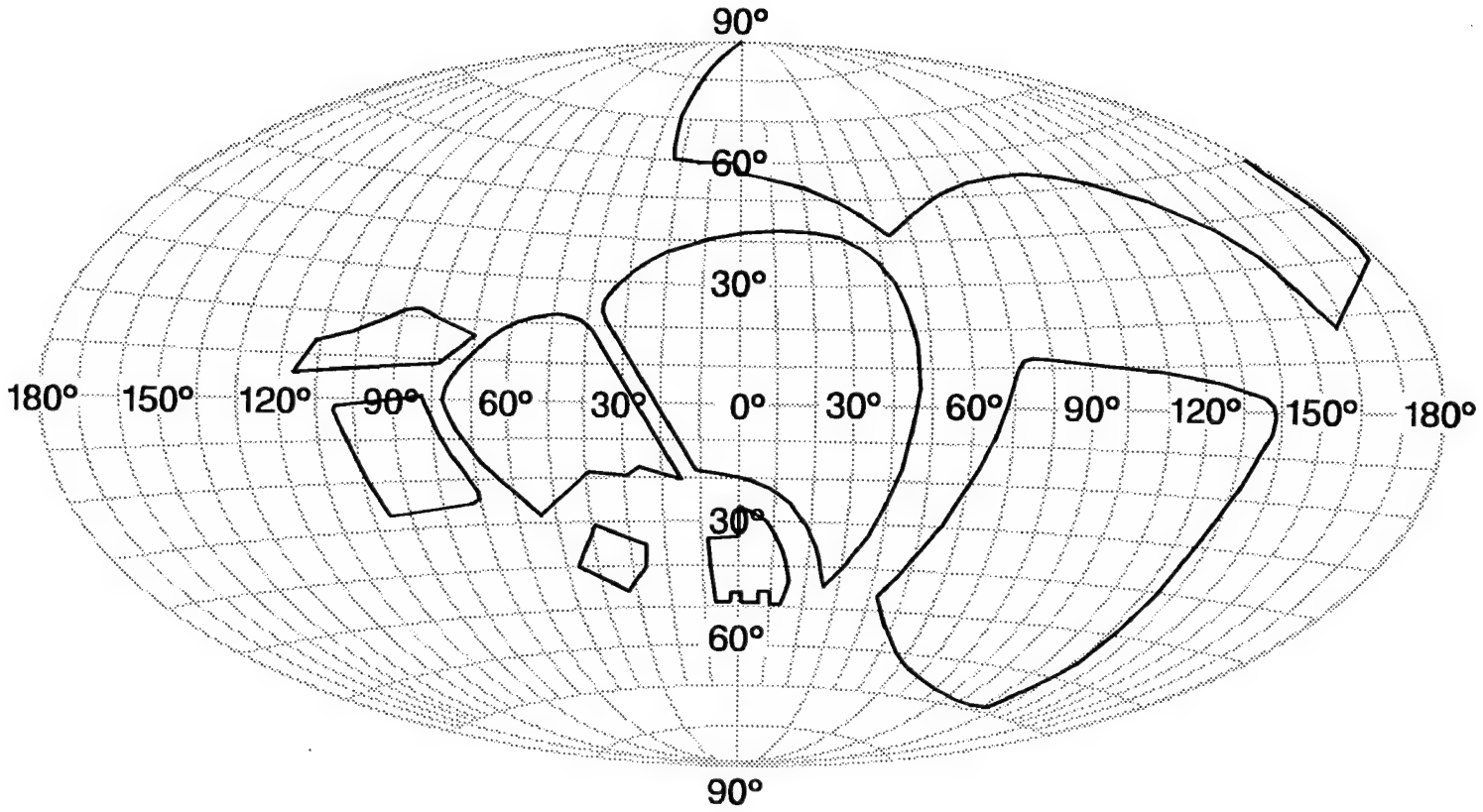

Figure A-7. Vision plot for OH-58D Kiowa .

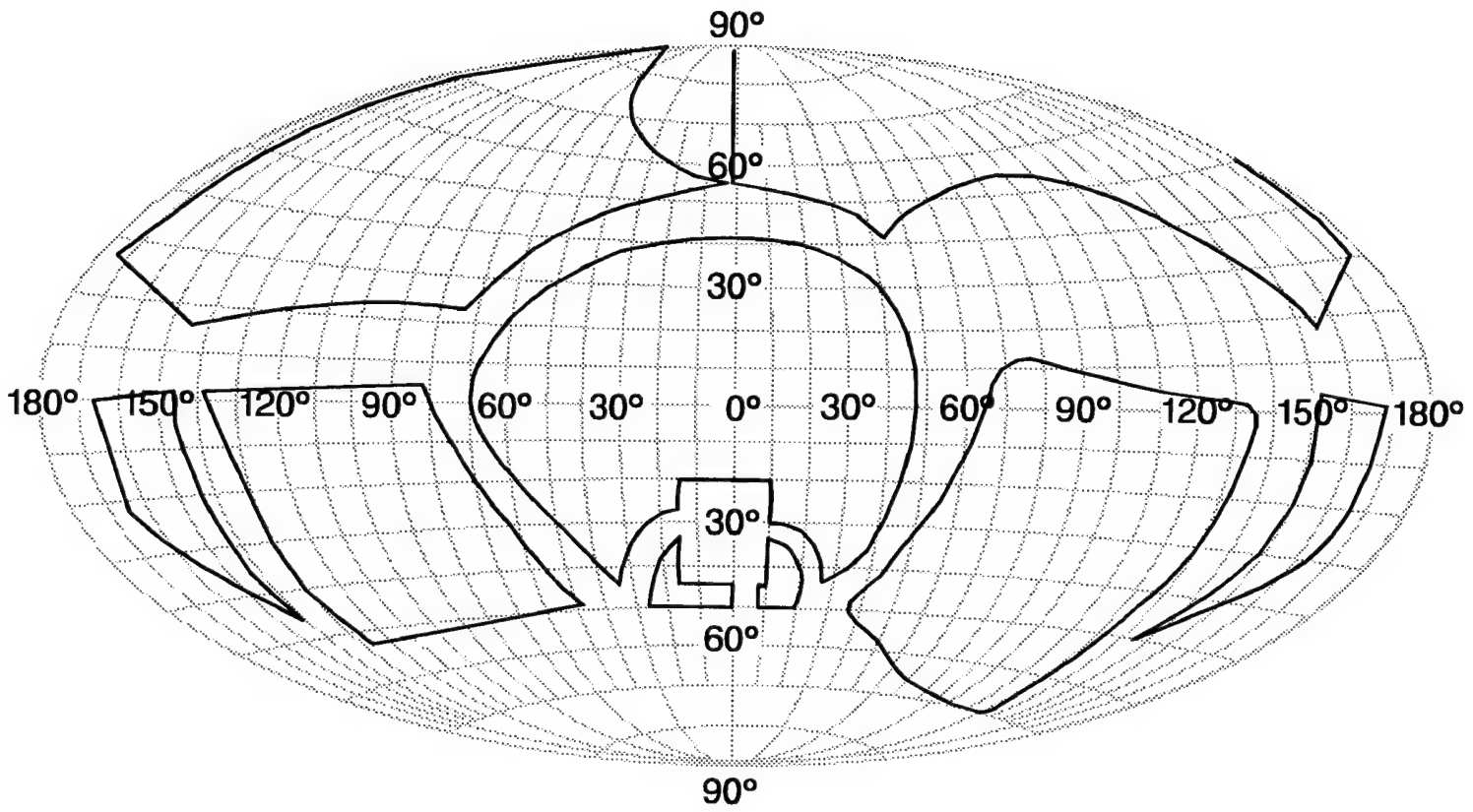

Figure A-8. Vision plot for TH-67 Creek.

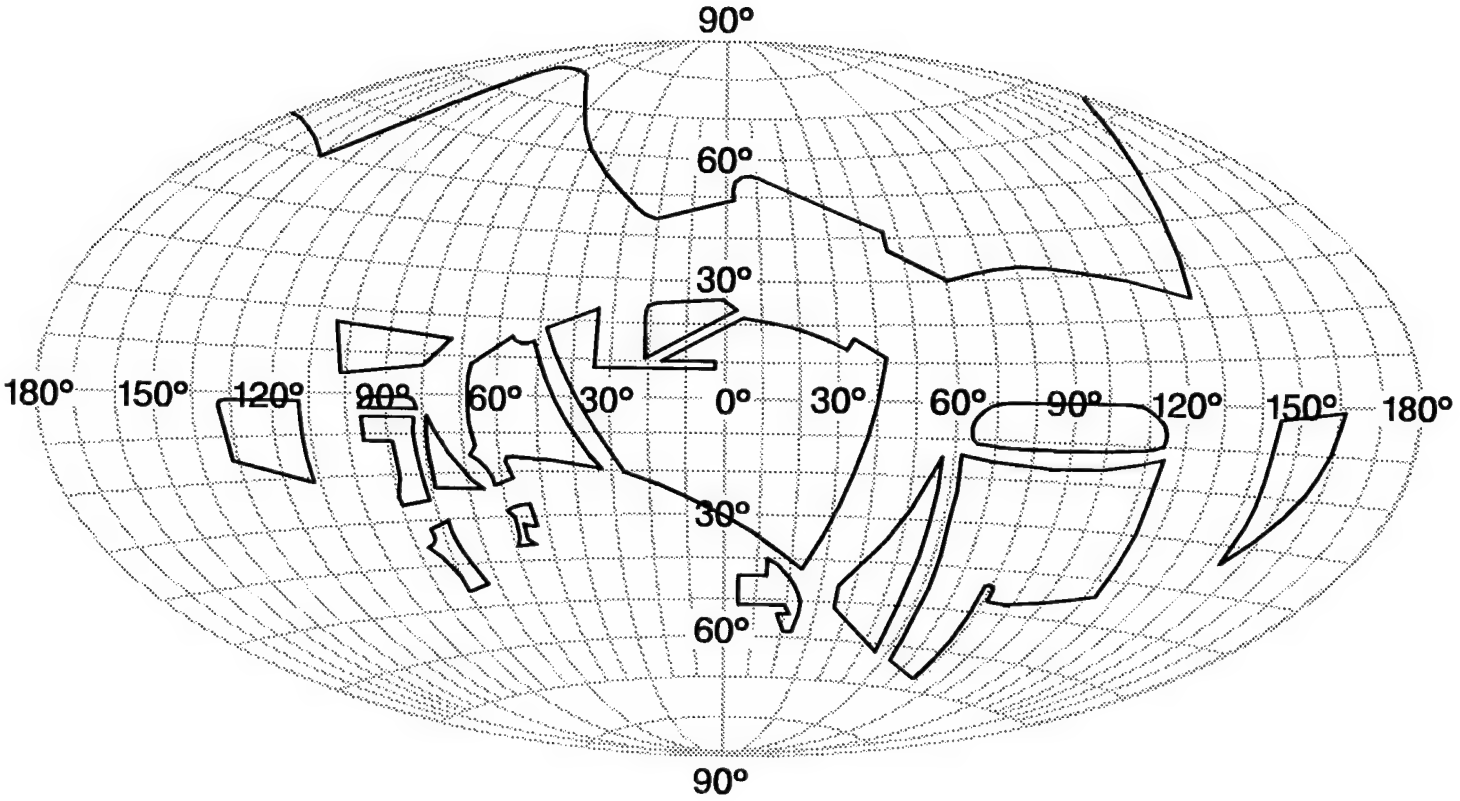

Figure A-9. Vision plot for UH-1H Iroquois.

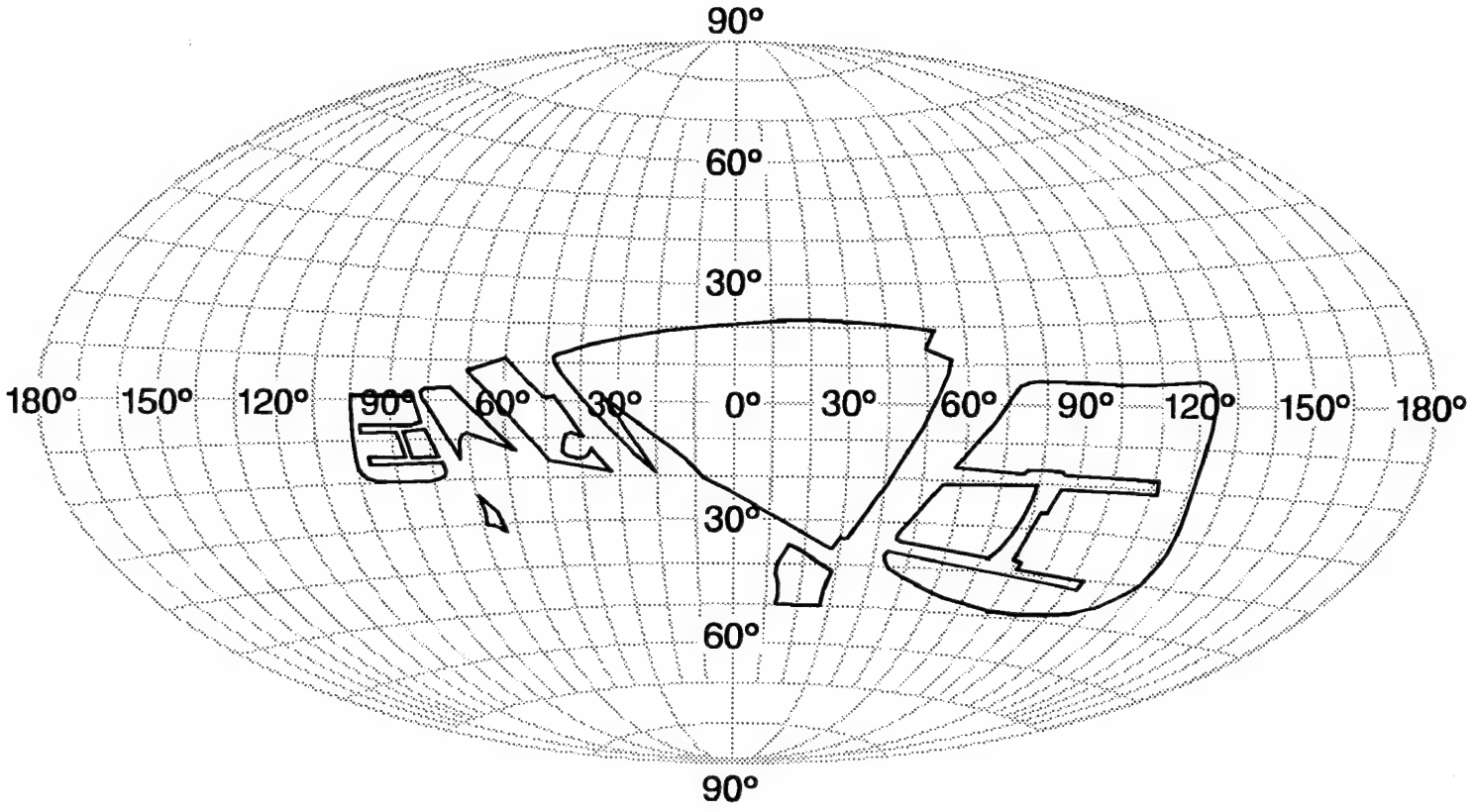

Figure A-10. Vision plot for UH-60A Black Hawk.

Appendix B.

Pilot/copilot utilization questionnaire

Pilot/copilot
View Port Utilization Questionnaire

In an effort to aid in the improvement of tactical operations in rotary-winged aircraft, the U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, Alabama is studying the external vision afforded by the aircraft. The primary interest of the study is the location and extent of current visual ports (windscreens) in the aircraft.

It is important that you answer the questions as accurately and fully as possible. These data will be used as a data base for accident investigation and for a reference in future design of the visual field in the aircraft.

Both you and your responses will remain anonymous. The data collected will be used for research purposes only. They will not become part of your record, nor will they be used to make any determination about you.

Please answer the appropriate questions for the primary aircraft that you have flown in the last 6 months. For any additional aircraft you have flown during this period, please fill out a separate form. Your sincere consideration and time will be greatly appreciated.

If you have any questions, please contact LTC Levine at 205-255-6868 (DSN 558-6814).

Thank you.

Please circle the appropriate response:

Sex: Male Female

Primary crew station: pilot copilot

Primary aircraft type during the last 6-months:

AH-1 AH-64 CH-47 OH-6 OH-58A UH-1 UH-60 TH-67 OH-58C OH-58D

Accumulated flight hours in primary aircraft: _____

Total flight hours in rotary-winged aircraft:_____

Please check and/or comment on the appropriate questions. Some questions may not apply to all aircraft.

1. Which tasks do you accomplish through the front windscreens while performing hover/taxi?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft avoidance
___ landing point reference
___ target acquisition/detection
___ other (specify) _____

___ ground clearance
___ visual orientation
___ target engagement
___ reconnaissance

_____

2. Identify any problems that you have experienced with the front windscreens while performing hover/taxi:

___ too small of an area
___ improper placement
___ glare from interior lights
___ glare from external lights
___ distortion caused by curvature
___ distortion due to the moisture removal system of the aircraft(defog wiring, gold inlay, etc.)
___ vision blockage due to interior design
___ vision blockage due to vertical and horizontal supports
___ vision blockage due to other add-on equipment/systems
___ no problems
Comments:_____

_____

3. Which tasks do you accomplish through the side windscreens while performing hover/taxi?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft avoidance
___ landing point reference
___ target acquisition/detection
___ other (specify) _____

___ ground clearance
___ visual orientation
___ target engagement
___ reconnaissance

4. Check any problems that you have experienced with the side windscreens performing hover/taxi:

___ too small in area
___ improper placement
___ glare from interior lights
___ glare from external lights
___ distortion caused by curvature
___ vision blockage due to interior design
___ vision blockage due to vertical and horizontal supports
___ vision blockage due to other add-on equipment/systems
___ no problems
Comments:_____

_____

5. Which tasks do you accomplish through the overhead windscreens while performing hover/taxi?

___ pilotage(NAV) ___ ground clearance
___ obstacle avoidance ___ visual orientation
___ aircraft clearance ___ target engagement
___ landing point reference ___ reconnaissance
___ target acquisition/detection
___ other (specify) _____

_____

6. Identify any problems that you have experienced with the overhead windscreens in hover/taxi:

___ too small of an area
___ improper placement
___ glare from external lights
___ glare from interior lights
___ distortion caused by curvature
___ vision blockage due to interior design
___ vision blockage due to vertical and horizontal supports
___ vision blockage due to other add-on equipment/systems
___ no problems
Comments:_____

_____

7. Which tasks do you perform through the front windscreens while performing terrain flight?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft avoidance
___ landing point reference
___ target acquisition/detection
___ other (specify) _____

___ ground clearance
___ visual orientation
___ target engagement
___ reconnaissance

_____

8. Identify any problems that you have experienced with the front windscreens in terrain flight:

___ too small of an area
___ improper placement
___ glare from interior lights
___ glare from external lights
___ distortion caused by curvature
___ distortion due to the moisture removal system of the aircraft(defog wiring, gold inlay, etc.)
___ vision blockage due to interior design
___ vision blockage due to vertical and horizontal supports
___ vision blockage due to other add-on equipment/systems
___ no problems
Comments:_____

_____

9. Which tasks do you perform through the side windscreens in terrain flight?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft avoidance
___ landing point reference
___ target acquisition/detection
___ other (specify) _____

___ ground clearance
___ visual orientation
___ target engagement
___ reconnaissance

_____

10. Check any problems that you have experienced with the side windscreens in terrain flight:

___ too small in area
___ improper placement
___ glare from interior lights
___ glare from external lights
___ distortion caused by curvature
___ vision blockage due to interior design
___ vision blockage due to vertical and horizontal supports
___ vision blockage due to other add-on equipment/systems
___ no problems
Comments:_____

_____

11. Which tasks do you accomplish through the overhead windscreens while performing terrain flight?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft clearance
___ landing point reference
___ target acquisition/detection
___ other (specify) _____
___ ground clearance
___ visual orientation
___ target engagement
___ reconnaissance

_____

12. Identify any problems that you have experienced with the overhead windscreens in terrain flight:

___ too small of an area
___ improper placement
___ glare from external lights
___ glare from interior lights
___ distortion caused by curvature
___ vision blockage due to interior design
___ vision blockage due to vertical and horizontal supports
___ vision blockage due to other add-on equipment/systems
___ no problems
Comments:_____

_____

13. Which tasks do you accomplish through the front windscreens while performing above terrain flight?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft avoidance
___ landing point reference
___ target acquisition/detection
___ other (specify) _____

___ ground clearance
___ visual orientation
___ target engagement
___ reconnaissance

_____

14. Identify any problems that you have experienced with the front windscreens in above terrain flight:

___ too small of an area
___ improper placement
___ glare from interior lights
___ glare from external lights
___ distortion caused by curvature
___ distortion due to the moisture removal system of the aircraft(defog wiring, gold inlay, etc.)
___ vision blockage due to interior design
___ vision blockage due to vertical and horizontal supports
___ vision blockage due to other add-on equipment/systems
___ no problems
Comments:_____

_____

15. Which tasks do you accomplish through the side windscreens while performing above terrain flight?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft avoidance
___ landing point reference
___ target acquisition/detection
___ other (specify) _____

___ ground clearance
___ visual orientation
___ target engagement
___ reconnaissance

_____

16. Check any problems that you have experienced with the side windscreens in above terrain flight:

___ too small in area
___ improper placement
___ glare from interior lights
___ glare from external lights
___ distortion caused by curvature
___ vision blockage due to interior design
___ vision blockage due to vertical and horizontal supports
___ vision blockage due to other add-on equipment/systems
___ no problems
Comments:_____

_____

17. Which tasks do you accomplish through the overhead windscreens while performing above terrain flight?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft clearance
___ landing point reference
___ target acquisition/detection
___ other (specify) _____
___ ground clearance
___ visual orientation
___ target engagement
___ reconnaissance

_____

18. Identify any problems that you have experienced with the overhead windscreens in above terrain flight:

___ too small of an area
___ improper placement
___ glare from external lights
___ glare from interior lights
___ distortion caused by curvature
___ vision blockage due to interior design
___ vision blockage due to vertical and horizontal supports
___ vision blockage due to other add-on equipment/systems
___ no problems
Comments:_____

_____

CH-47, OH-58, OH-6, TH-67, UH-1, UH-60 only

19. Which tasks do you accomplish through the chin bubbles while performing hover/taxi?

___ pilotage(NAV) ___ ground clearance
___ obstacle avoidance ___ visual orientation
___ aircraft avoidance ___ target engagement
___ landing point clearance ___ reconnaissance
___ target acquisition/detection
___ other (specify) _____

_____

CH-47, OH-58, OH-6, TH-67, UH-1, UH-60 only

20. Identify any problems that you have experienced with the chin bubbles while performing hover/taxi:

___ too small of an area
___ glare from external lights
___ glare from interior lights
___ improper placement
___ distortion caused by curvature
___ vision blockage due to interior design
___ vision blockage due to vertical and horizontal supports
___ vision blockage due to other add-on equipment/systems
___ no problems
Comments:_____

_____

CH-47, OH-58, OH-6, TH-67, UH-1, UH-60 only

21. Which tasks do you accomplish through the chin bubbles while performing terrain flight?

___ pilotage(NAV) ___ ground clearance
___ obstacle avoidance ___ visual orientation
___ aircraft avoidance ___ target engagement
___ landing point clearance ___ reconnaissance
___ target acquisition/detection
___ other (specify) _____

_____

CH-47, OH-58, OH-6, TH-67, UH-1, UH-60 only

22. Identify any problems that you have experienced with the chin bubbles in performing terrain flight:
    - ___ too small of an area
    - ___ glare from external lights
    - ___ glare from interior lights
    - ___ improper placement
    - ___ distortion caused by curvature
    - ___ vision blockage due to interior design
    - ___ vision blockage due to vertical and horizontal supports
    - ___ vision blockage due to other add-on equipment/systems
    - ___ no problems

    Comments:_____

    _____

CH-47, OH-58, OH-6, TH-67, UH-1, UH-60 only

23. Which tasks do you accomplish through the chin bubbles while performing above terrain flight?
    - ___ pilotage(NAV)
    - ___ obstacle avoidance
    - ___ aircraft avoidance
    - ___ landing point clearance
    - ___ target acquisition/detection
    - ___ other (specify) _____
    - ___ ground clearance
    - ___ visual orientation
    - ___ target engagement
    - ___ reconnaissance

    _____

CH-47, OH-58, OH-6, TH-67, UH-1, UH-60 only

24. Identify any problems that you have experienced with the chin bubbles in above terrain flight:
    - ___ too small of an area
    - ___ glare from external lights
    - ___ glare from interior lights
    - ___ improper placement
    - ___ distortion caused by curvature
    - ___ vision blockage due to interior design
    - ___ vision blockage due to vertical and horizontal supports
    - ___ vision blockage due to other add-on equipment/systems
    - ___ no problems

    Comments:_____

    _____

25. Rate the overall external viewability through present windows in the aircraft:

__very poor __poor __borderline __good __very good

If less than good, to what do you attribute this?

_____

_____

26. Are there any external aircraft components that you would like to periodically visually check during flight that you can not normally see?

___ yes ___ no

If yes, which component(s) do you like to see?

_____

How would you suggest accomplishing this task (mirrors, larger window, chin bubbles, etc.)?

_____

_____

27. Which type of windscreen configuration would you prefer?

___ One with flat windows and window support posts, or

___ Continuous one piece curved windscreens without posts but with related distortion problems.

28. Identify any problems you have experienced due to windscreen material by placing a **G** for glass, **P** for plexiglass, and a **O** for other material(_____).

___ distortion(waviness)
___ haze
___ scratches due to improper cleaning
___ scratches from the environment
___ other(specify)_____

___ chipping
___ frequent replacement
___ cracks
___ crazing

_____

29. Has the location of a window ever caused object/image displacement problems (prismatic deviation)?

___ yes ___ no

If yes, please explain:_____

_____

_____

30. Is there a visual port(window) placed such that flicker vertigo is a reoccurring problem?

___ yes ___ no

If yes, please explain:_____

_____

31. Are you able to adjust your seat in the aircraft to obtain what you would consider an optimal pilot-eye-position for your aircraft?

___ yes ___ no

If not, please explain:_____

_____

AH-1 and AH-64 only

32. From your experience in attack type helicopters with tandem seating, which seating arrangement would you prefer when considering the visual requirements for that mission?

___ Pilot in the aft seat, copilot/gunner in front

___ Pilot in the front seat, copilot/gunner in the aft

33. Does the use of helmet-mounted devices (e.g., NVGs, ANVIS) cause any additional conflicts with the external vision in the aircraft?

___ yes ___ no

If yes, please explain:_____

_____

_____

34. Please comment on any other problems regarding windscreens (no matter how general or specific in nature) not previously addressed:

_____

_____

_____

If applicable, please acquire at this time a second questionnaire for any additional aircraft.

Appendix C.

Crewman utilization questionnaire

Crew
View Port Utilization Questionnaire

In an effort to aid in the improvement of tactical operations in rotary-winged aircraft, the U.S. Army Aeromedical Laboratory (USAARL) at Fort Rucker is studying the external vision afforded by the aircraft. The primary interest of the study is the location and extent of the current visual ports(windscreens) in the aircraft.

It is important that you answer the questions as accurately and fully as possible. These data will be used as a data base for accident investigation and for a reference in future design of the visual field in the aircraft.

Both you and your responses will remain anonymous. The data collected will be used for research purposes only. They will not become part of your record, nor will they be used to make any determination about you.

Please answer the appropriate questions for the primary aircraft that you have served on in the last 6 months. For any additional aircraft you have served on during this period, please fill out a separate form. Your sincere consideration and time will be greatly appreciated.

If you have any questions, please contact Ed Rash at 205-255-6814.

Thank you.

Please circle the appropriate response:

Sex: Male Female

Primary aircraft type during the last 6 months:

CH-47 OH-58A OH-58C UH-1 UH-60

Accumulated flight hours in primary aircraft:_____

Total rotary-winged flight hours:_____

Please check and/or comment on the appropriate questions. Some questions may not apply to all aircraft.

1. Which tasks do you perform accomplish through the rear ports/door windows/gunner windows while performing hover/taxi?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft avoidance
___ landing point clearance
___ target acquisition/detection
___ ground clearance
___ aircraft clearance
___ target engagement
___ reconnaissance
___ none
___ check aircraft for mechanical and safety problems
___ other(specify)_____

_____

2. Check any problems that you have experienced with the rear ports/door windows/gunner windows while performing hover/taxi:

___ too small in area
___ improper placement
___ glare from interior lights
___ glare from external lights
___ distortion caused by curvature
___ vision blockage due to interior design
___ vision blockage due to other add-on equipment/systems
___ vision blockage due to vertical and horizontal supports
___ no problems
Comments:_____

_____

3. Which tasks do you accomplish through the rear ports/door windows/gunner windows while performing terrain flight?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft avoidance
___ landing point clearance
___ target acquisition/detection
___ ground clearance
___ aircraft clearance
___ target engagement
___ reconnaissance
___ none
___ check aircraft for mechanical and safety problems
___ other (specify) _____

4. Check any problems that you have experienced with the rear ports/door windows/gunner windows in terrain flight:

___ too small in area
___ improper placement
___ glare from interior lights
___ glare from external lights
___ distortion caused by curvature
___ vision blockage due to interior design
___ vision blockage due to other add-on equipment/systems
___ vision blockage due to vertical and horizontal supports
___ no problems
Comments:_____

_____

5. Which tasks do you accomplish through the rear ports/door windows/gunner windows in <u>above</u> terrain flight?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft avoidance
___ landing point clearance
___ target acquisition/detection
___ ground clearance
___ aircraft clearance
___ target engagement
___ reconnaissance
___ none
___ check aircraft for mechanical and safety problems
___ other (specify) _____

_____

6. Check any problems that you have experienced with the rear ports/door windows/gunner windows in <u>above</u> terrain flight:

___ too small in area
___ glare from interior lights
___ improper placement
___ glare from external lights
___ distortion caused by curvature
___ vision blockage due to interior design
___ vision blockage due to other add-on equipment/systems
___ vision blockage due to vertical and horizontal supports
___ no problems
Comments:_____

7. Which tasks do you perform through the front windscreens?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft avoidance
___ landing point clearance
___ target acquisition/detection
___ ground clearance
___ aircraft clearance
___ target engagement
___ reconnaissance
___ none
___ check aircraft for mechanical and safety problems
___ other(specify)_____

8. Check any problems that you have experienced with the front windscreens:

___ too small in area
___ improper placement
___ glare from interior lights
___ glare from external lights
___ distortion caused by curvature
___ vision blockage due to interior design
___ vision blockage due to other add-on equipment/systems
___ vision blockage due to vertical and horizontal supports
___ no problems
Comments:_____

CH-47 only 9. Which tasks do you perform through the bubble windows in the fuselage?

___ pilotage(NAV)
___ obstacle avoidance
___ aircraft avoidance
___ landing point clearance
___ target acquisition/detection
___ ground clearance
___ aircraft clearance
___ target engagement
___ reconnaissance
___ none
___ check aircraft for mechanical and safety problems
___ other(specify)_____

CH-47 only 10. Check any problems that you have experienced with the bubble windows in the fuselage:

___ too small in area
___ improper placement
___ glare from interior lights
___ glare from external lights
___ distortion caused by curvature
___ vision blockage due to interior design
___ vision blockage due to other add-on equipment/systems
___ vision blockage due to vertical and horizontal supports
___ no problems
Comments:_____

_____

11. Rate the overall external viewability through present windows in the aircraft:

__very poor __poor __borderline __good __very good

If less than good, to what do you attribute this?

_____

_____

12. Are there any external aircraft components that you would like to periodically visually check during flight that you can not normally see?

___ yes ___ no

If yes, which component(s) do you like to see?

_____

How would you suggest accomplishing this task (mirrors, larger window, new windows, chin bubbles, etc.)?

_____

_____

13. Identify any problems you have experienced due to windscreen material by placing a **G** for glass, **P** for plexiglass, and a **O** for other material(_____).

___ distortion(waviness) ___ chipping
___ haze ___ frequent replacement
___ scratches due to improper cleaning
___ scratches from the environment
___ cracks ___ crazing
___ other(specify)_____

_____
_____

14. Has the location of a window ever caused object/image displacement problems (prismatic deviation)?

___ yes ___ no

If yes, please explain:_____

_____

15. Does the use of helmet-mounted devices (e.g., NVGs, ANVIS) cause any additional conflicts with the external vision in the aircraft?

___yes ___no

If yes, please explain:_____

_____

16. Please comment on any other problems regarding windscreens (no matter how general or specific in nature) not previously addressed: _____

_____

_____

If applicable, please acquire a second questionnaire at this time for any additional aircraft.

Appendix D.

Pilot/copilot questionnaire data

The format for presenting the questionnaire data consists of stating each question and providing the percentage of respondents selecting each possible choice of response. Where appropriate, data also are presented by aircraft type, where the value reported represents the percentage of respondents for the particular aircraft type selecting each choice of response. For questions where comments were requested, representative comments were selected for inclusion in the following data on the basis of frequency of occurrence or uniqueness. [Note: For some comments, the frequency of occurrence is noted by inclusion in parentheses, e.g., (2).]

The AH-1 and AH-64 data represent pilot data only. Copilot/gunner data for these aircraft are presented in Appendix E.

1. Which tasks do you accomplish through the front windscreens while performing hover/taxi?

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
69% pilotage(NAV)	100%	67%	93%	66%	100%	69%	80%	68%	64%
98% obstacle avoidance	100%	100%	93%	100%	75%	100%	100%	100%	97%
95% aircraft avoidance	100%	97%	93%	100%	100%	97%	100%	97%	97%
84% landing point reference	57%	63%	93%	100%	100%	97%	100%	88%	83%
43% target acquisition/ detection	86%	77%	20%	66%	50%	74%	100%	21%	28%
77% ground clearance	71%	53%	60%	100%	75%	87%	100%	85%	79%
90% visual orientation	71%	77%	93%	83%	100%	95%	100%	97%	91%
29% target engagement	86%	73%	7%	50%	50%	54%	100%	15%	9%
59% reconnaissance	57%	63%	73%	50%	100%	74%	100%	47%	51%
2% other	0%	0%	0%	17%	0%	3%	0%	5%	1%

OH-6: "gunnery tasks"
UH-1: "hover maneuvers"
OH-58C: "Any maneuvers or tasks related to flying use front windscreens if a good scan is used."
UH-60: "pick up to hover"

2. Identify any problems that you have experienced with the front windscreens while performing hover/taxi:

All aircraft (n=257)		AH-1 (n=7)	AH-64 (n=30)	CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
25%	too small of an area	43%	23%	7%	0%	0%	23%	0%	0%	38%
6%	improper placement	14%	0%	0%	17%	0%	3%	0%	3%	9%
35%	glare from interior lights	29%	50%	53%	0%	25%	36%	0%	38%	31%
16%	glare from external lights	29%	13%	13%	33%	0%	41%	40%	6%	9%
13%	distortion caused by curvature	0%	13%	7%	17%	25%	28%	60%	3%	10%
19%	distortion due to the moisture removal system of the aircraft (defog wiring, gold inlay, etc.)	14%	20%	13%	0%	0%	23%	100%	15%	17%
54%	vision blockage due to interior design	29%	57%	53%	17%	50%	49%	0%	18%	71%
66%	vision blockage due to vertical and horizontal supports	57%	80%	53%	17%	100%	85%	40%	18%	74%
16%	vision blockage due to other add-on equipment/ systems	57%	13%	20%	33%	0%	39%	40%	0%	10%
10%	no problems	0%	7%	20%	17%	0%	0%	0%	44%	4%

Comments: CH-47: "Instrument panel is high."
"CH-47 requires high seat placement in order to see ground reference (which) is obscured by glare shield."
OH-58A: "rain disbursement, PDU, GPS"
OH-58C: "glare shield"
"Can't clear right 2-o'clock and left 10-o'clock positions."

3. Which tasks do you accomplish through the side windscreens while performing hover/taxi?
Note: The OH-6 routinely flies with doors removed.

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
55% pilotage(NAV)	86%	63%	73%	66%	50%	54%	40%	50%	50%
93% obstacle avoidance	100%	87%	93%	83%	100%	87%	100%	94%	95%
91% aircraft avoidance	86%	97%	93%	83%	75%	90%	80%	94%	91%
75% landing point reference	100%	83%	67%	83%	50%	67%	80%	74%	75%
31% target acquisition/ detection	71%	63%	7%	66%	25%	62%	40%	18%	14%
89% ground clearance	100%	87%	93%	83%	100%	87%	80%	85%	90%
87% visual orientation	100%	93%	93%	83%	75%	80%	100%	94%	84%
21% target engagement	57%	63%	0%	66%	0%	28%	40%	15%	7%
52% reconnaissance	71%	70%	47%	66%	75%	67%	80%	32%	44%
0% no response	0%	0%	0%	17%	0%	0%	0%	0%	0%
2% other	14%	7%	0%	17%	0%	0%	0%	3%	1%

AH-1: "vertical rate of movement"
AH-64: "rate of movement and drift" (1)
UH-1: "sidewards flight for control response checks"
UH-60: "pick up to hover"

4. Check any problems that you have experienced with the side windscreens performing hover/taxi:
Note: The OH-6 routinely fly with doors removed.

All aircraft (n=257)	AH-1 (n=7)	AH-64 (n=30)	CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
23% too small in area	0%	0%	13%	0%	50%	41%	60%	15%	27%
8% improper placement	0%	0%	0%	0%	25%	21%	40%	0%	8%
23% glare from interior lights	43%	47%	7%	0%	25%	31%	0%	21%	17%
12% glare from external lights	29%	20%	7%	0%	0%	18%	0%	6%	10%
14% distortion caused by curvature	0%	23%	7%	0%	0%	21%	0%	3%	17%
35% vision blockage due to interior design	14%	30%	20%	0%	50%	39%	40%	21%	43%
49% vision blockage due to vertical and horizontal supports	29%	37%	60%	0%	25%	36%	60%	35%	64%
7% vision blockage due to other add-on equipment/ systems	14%	7%	0%	0%	25%	21%	20%	3%	3%
23% no problems	29%	27%	40%	83%	0%	13%	20%	35%	18%
2% no response	0%	0%	0%	17%	0%	8%	0%	3%	1%

Comments: AH-1: "often lose other aircraft in width of supports"
"glare from lights real concern"
AH-64: "blind spot on both sides between front seat and back seat"
"circuit breaker block on left side blocks vision"; "glare from scratches"
CH-47: "antiquated door and window design"
OH-58A: "side armor panels"
OH-58C: "NVG helmet hits window.""air vents in line of sight"
UH-1: "dirty windscreens"

5. Which tasks do you accomplish through the overhead windscreens while performing hover/taxi?

All aircraft (n=257)	AH-1 (n=7)	AH-64 (n=30)	CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
2% pilotage(NAV)	0%	10%	0%	0%	0%	5%	0%	0%	0%
30% obstacle avoidance	57%	33%	7%	33%	25%	39%	0%	24%	31%
70% aircraft clearance	43%	67%	47%	66%	75%	56%	60%	74%	80%
2% landing point reference	0%	10%	0%	0%	0%	3%	0%	0%	0%
9% target acquisition/ detection	29%	17%	0%	33%	25%	26%	0%	3%	1%
2% ground clearance	0%	10%	0%	0%	0%	3%	0%	3%	0%
20% visual orientation	57%	23%	27%	33%	25%	15%	20%	15%	19%
6% target engagement	0%	17%	0%	17%	25%	10%	0%	6%	1%
7% reconnaissance	0%	7%	7%	17%	0%	13%	20%	9%	5%
1% none	14%	0%	0%	0%	25%	0%	0%	0%	0%
20% no response	0%	23%	40%	0%	0%	26%	20%	15%	18%
7% other	14%	7%	7%	0%	0%	13%	20%	9%	3%

Comments: AH-1: "horizontal plane of rotor disk"
"overhead canopy important in banking"
AH-64: "look for other aircraft"
CH-47: "too small"
OH-58C: "aircraft avoidance at altitude"

6. Identify any problems that you have experienced with the overhead windscreens in hover/taxi:

All aircraft (n=257)		AH-1 (n=7)	AH-64 (n=30)	CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
12%	too small of an area	0%	0%	7%	17%	25%	49%	20%	6%	4%
2%	improper placement	14%	0%	0%	0%	0%	8%	0%	0%	0%
4%	glare from external lights	0%	7%	0%	0%	0%	13%	0%	3%	2%
6%	glare from interior lights	0%	17%	13%	0%	0%	8%	0%	6%	3%
5%	distortion caused by curvature	0%	0%	7%	0%	0%	13%	0%	6%	3%
5%	vision blockage due to interior design	14%	3%	7%	17%	0%	13%	0%	0%	3%
11%	vision blockage due to vertical and horizontal supports	43%	13%	20%	17%	0%	13%	40%	6%	6%
2%	vision blockage due to other add-on equipment/ systems	0%	3%	0%	0%	25%	5%	0%	0%	2%
62%	no problems	57%	83%	53%	50%	50%	26%	60%	74%	68%
11%	no response	0%	0%	20%	0%	0%	28%	0%	6%	10%

Comments:
AH-1: "(no problems) except during rain"
AH-64: "glare front seat lights off of overhead canopy"
OH-58A: "hard to see through"
OH-58C: "scratches"; "discoloration"; "haze"; "crazed windows"
UH-60: "Clear plexiglass is too hot, they should be green like the UH-1S."
"Sun coming through bakes your helmet; ...easily scratched"

7. Which tasks do you perform through the front windscreens while performing terrain flight?

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
97% pilotage(NAV)	100%	97%	93%	100%	100%	97%	100%	100%	95%
97% obstacle avoidance	100%	100%	93%	100%	100%	97%	100%	100%	95%
96% aircraft avoidance	86%	100%	93%	100%	100%	97%	100%	100%	94%
77% landing point reference	57%	70%	87%	100%	100%	80%	80%	76%	77%
53% target acquisition/ detection	86%	80%	27%	100%	50%	87%	80%	35%	38%
84% ground clearance	86%	73%	80%	100%	100%	85%	80%	85%	85%
94% visual orientation	100%	93%	93%	100%	100%	95%	100%	91%	94%
40% target engagement	86%	83%	13%	100%	50%	74%	100%	15%	21%
67% reconnaissance	71%	80%	60%	100%	100%	82%	100%	53%	60%
0% no response	0%	0%	0%	0%	0%	0%	0%	0%	1%
0% other	0%	0%	0%	0%	0%	0%	0%	0%	0%

Comments: AH-1: "often must kick aircraft out of trim to see landing point reference"

8. Identify any problems that you have experienced with the front windscreens in terrain flight:

All aircraft (n=257)		AH-1 (n=7)	AH-64 (n=30)	CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
18%	too small of an area	29%	17%	7%	0%	25%	13%	0%	0%	28%
4%	improper placement	14%	0%	0%	0%	0%	3%	0%	0%	7%
30%	glare from interior lights	29%	47%	47%	0%	25%	23%	20%	24%	30%
15%	glare from external lights	29%	13%	20%	17%	25%	33%	20%	6%	11%
10%	distortion caused by curvature	0%	7%	7%	0%	25%	26%	20%	3%	8%
18%	distortion due to the moisture removal system of the aircraft (defog wiring, gold inlay, etc.)	29%	23%	20%	17%	0%	23%	60%	6%	16%
46%	vision blockage due to interior design	43%	53%	27%	17%	75%	41%	0%	18%	59%
59%	vision blockage due to vertical and horizontal supports	57%	70%	53%	17%	75%	69%	40%	18%	69%
16%	vision blockage due to other add-on equipment/ systems	29%	17%	20%	0%	25%	33%	40%	3%	13%
16%	no problems	0%	7%	40%	50%	0%	8%	40%	47%	7%
2%	no response	14%	0%	0%	0%	0%	3%	0%	0%	3%

Comments: AH-1: "HUD is bulky and often reflects sunlight"
AH-64: "rain buildup due to inadequate wipers"

CH-47: "glare shield"
OH-58A: "GPS, PDU, rain"
OH-58C: "vision degradation due to plexiglass crazing";
"(vision blockage from) ATAS PDU";
"OH-58C plate style windscreen...Any moisture on the windscreen will pool; up and obscure vision."
UH-60: "Dash obstructs vision."

9. Which tasks do you perform through the side windscreens in terrain flight?

All aircraft (n=257)	AH-1 (n=7)	AH-64 (n=30)	CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
84% pilotage(NAV)	86%	93%	73%	83%	75%	92%	60%	88%	80%
94% obstacle avoidance	100%	93%	93%	83%	100%	92%	100%	97%	93%
94% aircraft avoidance	100%	97%	93%	83%	75%	92%	80%	97%	95%
70% landing point reference	100%	83%	53%	83%	50%	67%	60%	59%	71%
42% target acquisition/ detection	71%	70%	13%	83%	50%	92%	80%	29%	20%
82% ground clearance	100%	90%	87%	83%	50%	72%	60%	91%	80%
88% visual orientation	86%	100%	73%	83%	100%	90%	80%	94%	85%
27% target engagement	71%	63%	0%	83%	0%	49%	40%	12%	11%
62% reconnaissance	71%	73%	53%	83%	75%	95%	100%	47%	49%
1% no response	0%	0%	0%	17%	0%	3%	0%	0%	1%
0% other	0%	0%	0%	0%	0%	0%	0%	0%	0%

Comments: OH-58C: "too small and improperly placed"

10. Check any problems that you have experienced with the side windscreens in terrain flight:

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
22% too small in area	0%	3%	7%	0%	75%	39%	40%	15%	26%
6% improper placement	0%	0%	7%	0%	25%	21%	0%	0%	4%
21% glare from interior lights	29%	53%	20%	0%	25%	21%	0%	12%	17%
13% glare from external lights	29%	20%	13%	0%	25%	26%	0%	3%	9%
12% distortion caused by curvature	14%	17%	7%	0%	0%	28%	40%	0%	9%
35% vision blockage due to interior design	14%	27%	20%	0%	50%	51%	40%	9%	44%
51% vision blockage due to vertical and horizontal supports	29%	43%	53%	0%	50%	46%	40%	32%	65%
8% vision blockage due to other add-on equipment/ systems	14%	7%	7%	0%	25%	15%	60%	3%	4%
25% no problems	43%	20%	40%	83%	0%	13%	20%	41%	20%
3% no response	0%	0%	0%	17%	0%	8%	0%	3%	2%

Comments: AH-1: "ADR data system on right side"
AH-64: "glare from scratches (in windscreen)"
"circuit breakers (block vision)"
OH-58A: "side armor panels"
OH-58C: "glare shield too large"
"air vents"
"side windows at eye level"

11. Which tasks do you accomplish through the overhead windscreens while performing terrain flight?

All aircraft (n=257)	AH-1 (n=7)	AH-64 (n=30)	CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
7% pilotage(NAV)	14%	23%	0%	17%	0%	5%	0%	0%	5%
35% obstacle avoidance	57%	37%	13%	83%	75%	36%	0%	41%	32%
69% aircraft clearance	71%	73%	53%	83%	25%	59%	40%	76%	74%
3% landing point reference	14%	13%	0%	0%	0%	3%	0%	3%	0%
16% target acquisition/ detection	43%	37%	7%	50%	25%	31%	0%	9%	5%
3% ground clearance	14%	17%	0%	0%	0%	3%	0%	3%	0%
25% visual orientation	29%	40%	27%	66%	50%	21%	40%	9%	22%
7% target engagement	14%	27%	0%	50%	0%	10%	0%	0%	2%
8% reconnaissance	14%	17%	20%	17%	0%	10%	20%	6%	3%
3% none	0%	17%	7%	0%	0%	0%	20%	0%	0%
15% no response	0%	0%	33%	17%	0%	28%	20%	6%	16%
2% other	0%	0%	13%	0%	0%	0%	0%	3%	2%

Comments: CH-47: "ground clearance/avoidance"
OH-58C: "bridges"
UH-1: "steep bank - visual targeting through overhead windscreen"
UH-60: "overhead weather observation"

12. Identify any problems that you have experienced with the overhead windscreens in terrain flight:

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
13% too small of an area	0%	3%	7%	0%	25%	44%	0%	9%	8%
2% improper placement	0%	0%	0%	0%	0%	10%	0%	0%	1%
5% glare from external lights	14%	10%	0%	17%	0%	5%	0%	6%	3%
8% glare from interior lights	29%	27%	13%	0%	0%	5%	0%	6%	4%
3% distortion caused by curvature	0%	7%	7%	0%	0%	5%	0%	3%	2%
8% vision blockage due to interior design	0%	3%	7%	0%	0%	15%	0%	3%	9%
14% vision blockage due to vertical and horizontal supports	14%	27%	20%	17%	0%	15%	20%	6%	12%
0% vision blockage due to other add-on equipment/ systems	0%	0%	0%	0%	0%	3%	0%	0%	1%
52% no problems	29%	60%	47%	33%	75%	18%	80%	76%	56%
14% no response	0%	0%	20%	17%	0%	33%	0%	6%	15%
1% other:	0%	0%	0%	33%	0%	0%	0%	0%	0%

OH-6: "dark due to window tinting"
"Green tint affects NVG operations."

Comments: AH-64: "glare from (lights) in front seat"
"glare from switches"
OH-58A: "poor to see through"

13. Which tasks do you accomplish through the front windscreens while performing above terrain flight?

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
97% pilotage(NAV)	100%	97%	87%	100%	100%	95%	100%	100%	97%
80% obstacle avoidance	100%	80%	73%	100%	75%	72%	80%	91%	79%
94% aircraft avoidance	100%	97%	93%	100%	100%	92%	100%	97%	93%
61% landing point reference	57%	67%	87%	50%	50%	54%	60%	74%	57%
50% target acquisition/ detection	71%	83%	20%	100%	50%	64%	60%	29%	43%
50% ground clearance	57%	53%	53%	100%	25%	44%	60%	53%	48%
89% visual orientation	100%	97%	80%	100%	100%	87%	100%	91%	87%
32% target engagement	71%	77%	7%	83%	25%	49%	80%	18%	16%
56% reconnaissance	71%	70%	53%	100%	75%	77%	80%	44%	45%
1% no response	0%	3%	0%	0%	0%	3%	0%	0%	1%
0% other	0%	0%	7%	0%	0%	0%	0%	0%	0%

Comments: CH-47: "(locating) clouds"

14. Identify any problems that you have experienced with the front windscreens in above terrain flight:

All aircraft (n=257)	AH-1 (n=7)	AH-64 (n=30)	CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
16% too small of an area	14%	13%	7%	0%	0%	15%	0%	3%	24%
3% improper placement	14%	0%	0%	0%	0%	3%	0%	0%	4%
28% glare from interior lights	43%	43%	47%	0%	25%	26%	20%	26%	24%
15% glare from external lights	29%	17%	13%	17%	25%	28%	0%	9%	11%
10% distortion caused by curvature	0%	10%	7%	0%	0%	28%	20%	3%	8%
16% distortion due to the moisture removal system of the aircraft (defog wiring, gold inlay, etc.)	29%	30%	20%	17%	0%	15%	60%	9%	12%
43% vision blockage due to interior design	29%	43%	27%	17%	25%	46%	20%	15%	57%
52% vision blockage due to vertical and horizontal supports	29%	57%	53%	17%	25%	67%	40%	18%	61%
16% vision blockage due to other add-on equipment/systems	43%	17%	20%	0%	25%	36%	40%	3%	10%
21% no problems	14%	13%	40%	50%	50%	8%	40%	41%	17%
1% no response	0%	0%	0%	0%	0%	3%	0%	3%	1%

Comments: AH-64: "fire control panel too tall (to see over)"
OH-58A: "PDU"
OH-58C: "water on flat panel"

15. Which tasks do you accomplish through the side windscreens while performing above terrain flight?

All aircraft (n=257)	AH-1 (n=7)	AH-64 (n=30)	CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
87% pilotage(NAV)	100%	90%	87%	83%	75%	90%	60%	91%	86%
78% obstacle avoidance	100%	80%	80%	83%	75%	72%	80%	91%	73%
94% aircraft avoidance	100%	97%	93%	83%	100%	95%	100%	100%	91%
53% landing point reference	71%	67%	67%	66%	25%	49%	60%	56%	46%
37% target acquisition/ detection	71%	70%	7%	83%	25%	54%	80%	32%	23%
50% ground clearance	71%	60%	60%	66%	25%	36%	60%	53%	49%
83% visual orientation	100%	90%	87%	83%	100%	82%	80%	94%	77%
25% target engagement	71%	60%	7%	83%	0%	33%	40%	18%	12%
50% reconnaissance	71%	67%	53%	83%	50%	74%	60%	44%	35%
2% no response	0%	3%	0%	0%	0%	5%	0%	0%	1%
1% other	0%	0%	7%	0%	0%	0%	0%	0%	2%

Comments: CH-47: "(locating) clouds"
UH-60: "distance estimation"
"rate of closure"

16. Check any problems that you have experienced with the side windscreens in above terrain flight:

All aircraft (n=257)	AH-1 (n=7)	AH-64 (n=30)	CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
15% too small in area	0%	3%	7%	0%	75%	33%	60%	6%	14%
4% improper placement	0%	0%	7%	0%	25%	13%	0%	3%	2%
16% glare from interior lights	29%	43%	20%	0%	0%	23%	0%	18%	8%
10% glare from external lights	29%	20%	13%	0%	0%	21%	0%	9%	3%
9% distortion caused by curvature	14%	17%	7%	0%	0%	23%	0%	0%	5%
24% vision blockage due to interior design	14%	17%	20%	0%	50%	46%	40%	15%	22%
35% vision blockage due to vertical and horizontal supports	43%	33%	60%	0%	50%	44%	60%	24%	33%
6% vision blockage due to other add-on equipment/ systems	14%	7%	7%	0%	10%	15%	20%	3%	2%
26% no problems	57%	33%	40%	66%	0%	18%	40%	50%	14%
2% no response	0%	0%	0%	33%	0%	3%	0%	3%	1%

Comments: AH-64: "glare from scratches"
"circuit breakers (block vision)"
OH-58C: "vents (side windows)"

17. Which tasks do you accomplish through the overhead windscreens while performing above terrain flight?

All aircraft (n=257)	AH-1 (n=7)	AH-64 (n=30)	CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
8% pilotage(NAV)	14%	23%	0%	50%	0%	10%	0%	3%	3%
26% obstacle avoidance	43%	40%	27%	100%	50%	28%	20%	35%	13%
56% aircraft clearance	57%	73%	73%	83%	50%	62%	40%	82%	40%
5% landing point reference	0%	17%	0%	50%	0%	5%	20%	3%	0%
12% target acquisition/ detection	14%	27%	0%	66%	25%	23%	20%	6%	4%
4% ground clearance	0%	17%	0%	50%	0%	3%	0%	6%	0%
24% visual orientation	43%	50%	27%	66%	25%	23%	40%	15%	15%
8% target engagement	0%	30%	0%	66%	0%	13%	0%	6%	1%
9% reconnaissance	0%	27%	13%	50%	0%	10%	20%	9%	2%
4% none	14%	13%	27%	0%	0%	0%	20%	0%	0%
8% no response	14%	3%	0%	0%	0%	21%	0%	3%	8%
3% other	0%	3%	0%	0%	0%	3%	0%	6%	3%

Comments: AH-64: "aircraft avoidance"
OH-58C: "aircraft at altitude"
"bridges"
UH-60: "weather observation"

18. Identify any problems that you have experienced with the overhead windscreens in above terrain flight:

All aircraft (n=257)	AH-1 (n=7)	AH-64 (n=30)	CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
11% too small of an area	0%	7%	7%	17%	25%	33%	0%	6%	8%
2% improper placement	0%	0%	0%	17%	0%	5%	0%	0%	1%
7% glare from external lights	14%	17%	7%	33%	0%	8%	0%	6%	3%
10% glare from interior lights	29%	33%	13%	17%	0%	10%	0%	6%	4%
5% distortion caused by curvature	0%	0%	7%	17%	0%	8%	0%	6%	4%
9% vision blockage due to interior design	43%	7%	7%	17%	0%	13%	0%	3%	9%
14% vision blockage due to vertical and horizontal supports	29%	27%	20%	33%	0%	18%	0%	6%	9%
2% vision blockage due to other add-on equipment/ systems	0%	7%	0%	17%	0%	3%	0%	0%	1%
56% no problems	57%	57%	47%	50%	50%	26%	0%	76%	63%
14% no response	0%	0%	20%	0%	0%	36%	0%	3%	15%
0% other: OH-58A: "scratches"	0%	0%	0%	0%	25%	0%	0%	0%	0%

Comments: AH-64: "glare from scratches"
OH-58C: "seats too far forward"

19. Which tasks do you accomplish through the chin bubbles while performing hover/taxi?

All aircraft (n=220)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
14% pilotage(NAV)	27%	33%	0%	31%	0%	21%	4%
67% obstacle avoidance	87%	100%	25%	85%	80%	74%	56%
18% aircraft avoidance	27%	33%	25%	33%	0%	24%	9%
80% landing point clearance	87%	100%	75%	85%	60%	94%	73%
6% target acquisition/detection	7%	33%	0%	10%	0%	6%	3%
83% ground clearance	93%	100%	100%	90%	80%	88%	77%
50% visual orientation	67%	66%	75%	46%	60%	32%	53%
3% target engagement	0%	33%	0%	3%	0%	6%	2%
13% reconnaissance	27%	50%	0%	15%	0%	21%	7%
6% no response	0%	0%	0%	8%	0%	0%	8%
4% other	0%	0%	0%	3%	0%	0%	6%

OH-58C: "alignment with landing area"
UH-60: "dust landings"
"drift"

20. Identify any problems that you have experienced with the chin bubbles while performing hover/taxi:

All aircraft (n=220)		CH-47 (n=15)	OH-6 (n=6)	OH-58A (n=4)	OH-58C (n=39)	OH-58D (n=5)	UH-1 (n=34)	UH-60 (n=117)
39%	too small of an area	0%	0%	25%	31%	40%	15%	57%
10%	glare from external lights	20%	0%	25%	13%	0%	15%	6%
6%	glare from interior lights	20%	0%	25%	8%	0%	3%	4%
5%	improper placement	0%	0%	0%	3%	0%	0%	9%
11%	distortion caused by curvature	13%	0%	0%	13%	20%	9%	12%
34%	vision blockage due to interior design	20%	33%	50%	44%	60%	12%	38%
13%	vision blockage due to vertical and horizontal supports	20%	0%	0%	8%	0%	6%	18%
6%	vision blockage due to other add-on equipment/ systems	13%	0%	0%	3%	40%	9%	4%
36%	no problems	47%	66%	50%	44%	20%	56%	25%
6%	no response	0%	0%	0%	8%	0%	6%	6%

Comments: OH-58C: "glare shields"
UH-1: "The pilot station's view is reduced by the instrument panel."
UH-60: "scratches"
"(need to be) bigger, further forward"

21. Which tasks do you accomplish through the chin bubbles while performing terrain flight?

All aircraft (n=220)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
25% pilotage(NAV)	33%	100%	25%	36%	40%	18%	17%
72% obstacle avoidance	80%	83%	75%	74%	60%	79%	68%
25% aircraft avoidance	33%	66%	25%	33%	20%	21%	20%
64% landing point clearance	73%	66%	75%	67%	40%	76%	58%
11% target acquisition/detection	7%	66%	0%	18%	0%	6%	9%
68% ground clearance	93%	83%	75%	69%	40%	88%	59%
50% visual orientation	67%	100%	50%	54%	60%	47%	44%
9% target engagement	0%	66%	0%	18%	0%	6%	3%
22% reconnaissance	33%	50%	0%	33%	0%	24%	17%
0% none	7%	0%	0%	0%	0%	0%	0%
8% no response	0%	0%	0%	15%	0%	3%	9%
2% other	0%	0%	0%	0%	0%	0%	3%

UH-60: "drift"
"too small for use"

22. Identify any problems that you have experienced with the chin bubbles in performing terrain flight:

All aircraft (n=220)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
36% too small of an area	7%	17%	50%	33%	40%	6%	50%
10% glare from external lights	20%	0%	50%	21%	0%	9%	4%
6% glare from interior lights	20%	0%	25%	10%	0%	3%	4%
6% improper placement	0%	0%	0%	8%	0%	0%	8%
10% distortion caused by curvature	20%	0%	0%	13%	20%	3%	10%
31% vision blockage due to interior design	27%	33%	50%	41%	60%	9%	32%
15% vision blockage due to vertical and horizontal supports	33%	17%	25%	8%	0%	3%	18%
4% vision blockage due to other add-on equipment/systems	7%	0%	0%	3%	40%	6%	3%
43% no problems	40%	66%	25%	41%	20%	71%	37%
2% no response	0%	0%	0%	5%	0%	0%	3%

Comments: OH-58C: "Ducts for defog and vents are too large."
"pedals in the way"
UH-60: "too small for use"

23. Which tasks do you accomplish through the chin bubbles while performing above terrain flight?

All aircraft (n=220)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
35% pilotage(NAV)	53%	100%	50%	44%	20%	44%	24%
48% obstacle avoidance	53%	83%	25%	56%	20%	62%	41%
44% aircraft avoidance	60%	66%	0%	54%	20%	62%	34%
39% landing point clearance	40%	50%	25%	44%	40%	41%	36%
11% target acquisition/detection	7%	66%	0%	31%	0%	12%	3%
39% ground clearance	40%	66%	50%	39%	40%	47%	35%
45% visual orientation	53%	66%	50%	49%	40%	56%	39%
5% target engagement	0%	50%	0%	10%	0%	9%	1%
23% reconnaissance	47%	50%	0%	26%	20%	38%	15%
2% none	20%	0%	0%	0%	20%	0%	0%
14% no response	0%	0%	0%	23%	0%	3%	18%
3% other	0%	0%	0%	0%	0%	0%	5%

UH-60: "land marking, only with poor visibility"

24. Identify any problems that you have experienced with the chin bubbles in above terrain flight:

All aircraft (n=220)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
29% too small of an area	7%	0%	50%	23%	0%	9%	42%
9% glare from external lights	13%	0%	25%	15%	0%	12%	5%
5% glare from interior lights	20%	0%	25%	8%	0%	3%	2%
5% improper placement	0%	0%	0%	8%	0%	0%	6%
9% distortion caused by curvature	20%	0%	0%	10%	0%	6%	9%
23% vision blockage due to interior design	20%	33%	50%	26%	40%	15%	22%
13% vision blockage due to vertical and horizontal supports	27%	17%	25%	10%	0%	3%	15%
5% vision blockage due to other add-on equipment/systems	7%	0%	25%	3%	40%	9%	3%
45% no problems	53%	66%	50%	31%	60%	62%	41%
8% no response	0%	0%	0%	13%	0%	3%	8%

Comments: OH-58C: "IR light"

25. Rate the overall external viewability through present windows in the aircraft:

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
3% very poor	0%	3%	0%	0%	0%	0%	0%	0%	6%
10% poor	14%	3%	0%	0%	0%	10%	0%	3%	17%
31% borderline	29%	33%	13%	0%	25%	28%	20%	3%	44%
44% good	57%	57%	53%	0%	75%	56%	60%	62%	30%
11% very good	0%	3%	33%	100%	0%	5%	20%	32%	3%

If less than good, to what do you attribute this?

AH-1: "structural supports, HUD, glare"
"horizontal supports of overhead canopy"
"not enough of a step-up between front and back seats"
AH-64: "structural supports limit visibility" (8)
"canopy structure"
CH-47: "cheap wiper system, average de-icing system"
OH-58C: "small door windows"
"stupid air vents"
"large dash"
"frames are too thick"
"Flat plate structural design hinders observation."
"at low speeds, condensation on windscreen"
OH-58D: "PDU system brings the viewability of pilot side down to very poor"
UH-60: "forward FOV restricted by instrument panels"(2)
"vertical and horizontal supports"
"front windscreens too small"(2)
"Glare shields block vision on landing and approach."(3)

26. Are there any external aircraft components that you would like to periodically visually check during flight that you can not normally see?

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
29% yes	43%	60%	7%	0%	50%	21%	20%	21%	29%
69% no	57%	37%	87%	83%	50%	77%	80%	79%	69%
3% no response	0%	3%	7%	17%	0%	3%	0%	0%	2%

If yes, which component(s) do you like to see?

AH-1: "tail boom"; "external engine area"; "landing wheels"
AH-64: "engine nacelles"(4); "6-o'clock (tail)"(9); "30-mm gun"(3); "wheels"(2); "nose gear boxes"; "wing stores"; "refuel area"
CH-47: "rear (of aircraft)"
OH-58A: "position lights; tail rotor"
OH-58C: "tail rotor system"(4); "skids"; "ATAS (stinger)"(4)
UH-1: "rear tail clearance"(5)
UH-60: "sling load"; "clear tail rotor"(2); "stabilator"; "wheels"; "cargo hook"

How would you suggest accomplishing this task (mirrors, larger window, chin bubbles, etc.)?

AH-1: "mirrors (3), camera"; "larger windows"
AH-64: "mirrors"(6); "larger windows"; "(gun) indicator"
CH-47: "camera"
OH-58A: "mirrors"
OH-58C: "rear window"; "doors off"; "Go to OH-6 or Hughes 500 design."; "larger windows";"mirrors"(3)
OH-58D: "larger window"
UH-1: "mirrors"(2)
UH-60: "mirrors"(2); "larger bubbles"; "less obstructions inside aircraft"; "TV cameras"

27. Which type of windscreen configuration would you prefer?

All aircraft (n=257)		**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
32%	one with flat windows and window support posts	57%	50%	47%	0%	50%	8%	0%	29%	35%
60%	continuous one piece curved windscreens without posts but with related distortion problems	29%	40%	40%	100%	50%	90%	100%	56%	58%
7%	no response	14%	10%	13%	0%	0%	3%	0%	15%	6%

28. Identify any problems you have experienced due to windscreen material by placing a **G** for glass, **P** for plexiglass, and a **O** for other material(_____).

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
POLYCARBONATE									
44% distortion	14%	33%	27%	33%	75%	64%	60%	35%	45%
13% chipping	0%	13%	7%	0%	50%	28%	20%	12%	8%
58% haze	43%	77%	40%	33%	50%	59%	60%	50%	59%
14% frequent replacement	14%	17%	13%	0%	25%	21%	40%	15%	11%
66% scratches due to improper cleaning	71%	77%	60%	33%	100%	85%	80%	62%	59%
59% scratches from the environment	43%	60%	33%	66%	50%	67%	100%	53%	60%
28% cracks	14%	20%	27%	50%	50%	31%	0%	32%	26%
38% crazing	29%	27%	53%	17%	25%	31%	60%	50%	39%
2% other	0%	3%	0%	0%	0%	5%	0%	0%	2%

OH-58C: "green top faded dull from sun"(2)
UH-60: "pitting"(2)

28. (Continued)

Identify any problems you have experienced due to windscreen material by placing a G for glass, **P** for plexiglass, and a **O** for other material(_____).

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
GLASS									
4% distortion	0%	0%	0%	0%	0%	0%	20%	0%	8%
19% chipping	0%	13%	7%	0%	25%	5%	20%	6%	32%
8% haze	14%	3%	7%	0%	0%	13%	0%	6%	9%
8% frequent replacement	0%	7%	0%	0%	0%	5%	0%	0%	15%
16% scratches due to improper cleaning	14%	10%	13%	0%	0%	0%	0%	35%	20%
28% scratches from the environment	14%	17%	13%	0%	25%	0%	20%	58%	35%
24% cracks	0%	20%	7%	0%	25%	13%	0%	15%	38%
5% crazing	0%	3%	7%	0%	0%	13%	0%	6%	4%
0% other:	0%	0%	0%	0%	0%	0%	0%	0%	0%
AH-1: "scratches and crazing are a serious problem"									
AH-64: "scratches from wipers"									
0% none	0%	3%	0%	0%	0%	0%	0%	0%	0%
7% no response	0%	7%	0%	0%	0%	3%	0%	6%	10%

29. Has the location of a window ever caused object/image displacement problems (prismatic deviation)?

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
9 % yes	14%	10%	7%	0%	0%	18%	0%	3%	8%
87 % no	86%	83%	87%	100%	100%	80%	100%	97%	85%
5 % no response	0%	7%	7%	0%	0%	3%	0%	0%	8%

If yes, please explain:

AH-1: "slight displacement where panes meet support"
AH-64: "formation flight for the back seat is made more difficult by the external support between the front and back seat"
"depth perception problems through front windows"
CH-47: "curved plexiglass"
OH-58C: "Chin bubbles distort ground."; "side windows"
UH-1: "movement of sight picture from front to side"
UH-60: "windscreen curves"

30. Is there a visual port(window) placed such that flicker vertigo is a reoccurring problem?

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
9% yes	14%	13%	7%	0%	0%	15%	0%	9%	6%
89% no	86%	83%	87%	100%	100%	77%	100%	91%	93%
2% no response	0%	3%	7%	0%	0%	8%	0%	0%	0%

If yes, please explain:

AH-1: "On bright days or when concentrating on flight instruments, flicker vertigo can occur through top canopy."
AH-64: "caused by glare from scratches"
"upper windscreens...from flicker caused by rotor blades"
"on top, but acceptable"
"sunlight going through the rotor system into the top canopy"
CH-47: "cargo 1-piece bubble canopy"
OH-58C: "greenhouse window"
UH-1: "overhead window, occasionally"
UH-60: "sunny day...flickering overhead"

31. Are you able to adjust your seat in the aircraft to obtain what you would consider an optimal pilot-eye-position for your aircraft?

Note: Seats on OH-6 and OH-58A/C/D aircraft are not adjustable.

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
31% yes	57%	83%	80%	0%	25%	3%	20%	82%	6%
68% no	43%	13%	20%	100%	75%	95%	80%	18%	93%
1% no response	0%	3%	0%	0%	0%	3%	0%	0%	1%

If not, please explain:

AH-1: "Back seat is unable to get optimal view especially for tall pilots who must lower seat to keep HSS from hitting the canopy."
"The helmet sight system scratches the overhead canopy."

AH-64: "can't see over dash"; "always some kind of structural obstruction"

CH-47: "tradeoff between visibility over glare shield and through chin bubble"
"The design of the dash does not allow this."
"To avoid blockage by the glare shield, the seat must be placed high...creating some difficulty in viewing instruments."

OH-6: "seats do not adjust"

OH-58C: "OH-58 seats don't adjust."

OH-58D: "seat is not adjustable"

UH-1: "seats too low for side windows"
"Best adjustments for outside makes it difficult to see some instruments."

UH-60: "too many obstructions"
"Seats are poorly positioned."
"hard to adjust seats"
"Seat adjustments constantly jam."

32. From your experience in attack type helicopters with tandem seating, which seating arrangement would you prefer when considering the visual requirements for that mission? **FOR AH-1 AND AH-64 ATTACK AIRCRAFT ONLY**

All aircraft (n=37)	**AH-1** (n=7)	**AH-64** (n=30)
48% pilot in the aft seat, copilot/gunner in front	71%	43%
46% pilot in the front seat, copilot/gunner in the aft	29%	50%
6% no response	0%	7%

Comments: AH-1: "There is better visibility in the front seat to assist in aircraft control. There must be some sort of technology to put the gunner and his sight in the back seat. The reason it is not done, my guess, is money."

33. Does the use of helmet-mounted devices (e.g., NVGs, ANVIS) cause any additional conflicts with the external vision in the aircraft?

All aircraft (n=257)	**AH-1** (n=7)	**AH-64** (n=30)	**CH-47** (n=15)	**OH-6** (n=6)	**OH-58A** (n=4)	**OH-58C** (n=39)	**OH-58D** (n=5)	**UH-1** (n=34)	**UH-60** (n=117)
36% yes	43%	20%	27%	33%	75%	54%	80%	21%	36%
46% no	43%	67%	60%	66%	0%	28%	0%	68%	42%
17% no response	14%	13%	7%	0%	25%	18%	20%	12%	21%

If yes, please explain:

AH-1: "outside to the side is difficult because goggles hit windscreen"
"Glare is especially bad under NVGs."

AH-64: "At 6' 4", wearing NVGs in the front seat, I do not have full range of motion of my neck and head."

CH-47: "NVGs contacts window posts (3)"

OH-6: "Posts get in the way"

"Glare of lights off windscreens is intensified (with) NVGs"

OH-58A: "door window and PDU"

OH-58C: "When you turn to look out door, head hits windscreen or support."(2)
"Larger aircrew members bump the NVGs on the interior."
"only when looking left, I must back away from the window"
"interior reflections"
"Pilot's PDU is a serious pain in the (omitted)."
"OH-58 with ATAS has PDU in center of field of view."
"When turning to look out the side, looking through the window vent has caused some disorientation while using NVGs."
"With doors on, its hard to turn your head to see out the window."

OH-58D: "with OH-58D doors on, the NVGs contact the door windscreen at times. (2)"
"OH-58D door frame post causes a blockage of FOV"

UH-1: "side windows too close"; "Improper flashlight filters cause problems."
"decreases visibility outside windscreen"
"hit side windows"; "limits outside visibility"

UH-60: "windscreen supports"
"side windows hard to use"(2)

34. Please comment on any other problems regarding windscreens (no matter how general or specific in nature) not previously addressed:

AH-1: "back seat forward viewing is a must in tandem aircraft"
"Pilot and instrumentation placement is important. It doesn't do the pilot any good if he sits up high for a good view and must bend over to read a gauge..."
"tough to get rid of glare on the side windscreen during NVG flight"

AH-64: "Doppler reflection"
"the AH-64 has windshield wipers which work marginally at best"
"AH-64 canopy removal system...the refuel port and the exit door are on the same side"
"blast shield has numerous scratches, bubbles"

CH-47: "hard to see (with) NVGs"(3)

OH-58C: "Water does not move off windscreen."(2)
"During NVG terrain flight, it is important that the aeroscout observer clear both his sector and also the pilot's sector. This is very difficult due to structural supports and the center pillar."
"Prefer curved over flat plate."
"Army needs to buy 'Mirror-Glaze' polish and Rain-X type products for windshields."
"Improving the quality and durability of the (windscreens) would reduce haze, glare, and distortion."

UH-60: "Get rid of plexiglass."
"NVG flight...doors off"

Appendix E.

Copilot/gunner attack aircraft questionnaire data

The format for presenting the questionnaire data consists of stating each question and providing the percentage of respondents selecting each possible choice of response. Where appropriate, data also are presented by aircraft type, where the value reported represents the percentage of respondents for the particular aircraft type selecting each choice of response. For questions where comments were requested, representative comments were selected for inclusion in the following data on the basis of frequency of occurrence or uniqueness.

1. Which tasks do you accomplish through the front windscreens while performing hover/taxi?

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
88%	pilotage(NAV)	75%	92%
94%	obstacle avoidance	100%	92%
94%	aircraft avoidance	100%	92%
100%	landing point reference	100%	100%
88%	target acquisition/ detection	100%	83%
88%	ground clearance	100%	83%
100%	visual orientation	100%	100%
81%	target engagement	100%	75%
88%	reconnaissance	100%	83%
0%	other	0%	0%

2. Identify any problems that you have experienced with the front windscreens while performing hover/taxi:

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
19%	too small of an area	0%	25%
0%	improper placement	0%	0%
50%	glare from interior lights	100%	33%
31%	glare from external lights	25%	33%
6%	distortion caused by curvature	0%	8%
44%	distortion due to the moisture removal system of the aircraft (defog wiring, gold inlay, etc.)	25%	50%
56%	vision blockage due to interior design	0%	75%
63%	vision blockage due to vertical and horizontal supports	100%	50%
50%	vision blockage due to other add-on equipment/ systems	50%	50%
25%	no problems	0%	33%

Comments: AH-64: "flying behind ORT presents problems during VFR approaches"
"PNVS"
"bugs"
"windscreen picks up sun glare"

3. Which tasks do you accomplish through the side windscreens while performing hover/taxi?

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
63%	pilotage(NAV)	75%	58%
94%	obstacle avoidance	100%	92%
94%	aircraft avoidance	100%	92%
88%	landing point reference	100%	83%
63%	target acquisition/detection	75%	58%
94%	ground clearance	100%	92%
94%	visual orientation	75%	100%
56%	target engagement	75%	50%
81%	reconnaissance	75%	83%
0%	other	0%	0%

4. Check any problems that you have experienced with the side windscreens performing hover/taxi:

Combined copilot/gunner (n=16)		AH-1 (n=4)	AH-64 (n=12)
0%	too small in area	0%	0%
0%	improper placement	0%	0%
56%	glare from interior lights	100%	42%
19%	glare from external lights	25%	17%
13%	distortion caused by curvature	0%	17%
13%	vision blockage due to interior design	0%	17%
38%	vision blockage due to vertical and horizontal supports	50%	33%
6%	vision blockage due to other add-on equipment/ systems	25%	0%
31%	no problems	0%	42%

5. Which tasks do you accomplish through the overhead windscreens while performing hover/taxi?

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
6%	pilotage(NAV)	0%	8%
38%	obstacle avoidance	25%	42%
69%	aircraft clearance	25%	83%
6%	landing point reference	0%	8%
19%	target acquisition/ detection	0%	25%
13%	ground clearance	25%	8%
31%	visual orientation	25%	33%
6%	target engagement	0%	8%
0%	reconnaissance	0%	0%
13%	no response	25%	8%
6%	other	0%	8%

AH-64: "aircraft avoidance"

6. Identify any problems that you have experienced with the overhead windscreens in hover/taxi:

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
0%	too small of an area	0%	0%
0%	improper placement	0%	0%
0%	glare from external lights	0%	0%
25%	glare from interior lights	75%	8%
0%	distortion caused by curvature	0%	0%
0%	vision blockage due to interior design	0%	0%
6%	vision blockage due to vertical and horizontal supports	25%	0%
0%	vision blockage due to other add-on equipment/ systems	0%	0%
63%	no problems	0%	83%
13%	other:	0%	17%

AH-64: "leaks" (2)

Comments: AH-1: "gets very dirty in rain"

7. Which tasks do you perform through the front windscreens while performing terrain flight?

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
94%	pilotage(NAV)	100%	92%
100%	obstacle avoidance	100%	100%
100%	aircraft avoidance	100%	100%
94%	landing point reference	75%	100%
81%	target acquisition/detection	75%	83%
81%	ground clearance	75%	83%
100%	visual orientation	100%	100%
88%	target engagement	100%	83%
88%	reconnaissance	100%	83%
0%	other	0%	0%

8. Identify any problems that you have experienced with the front windscreens in terrain flight:

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
38%	too small of an area	25%	42%
6%	improper placement	0%	8%
50%	glare from interior lights	100%	33%
31%	glare from external lights	25%	33%
19%	distortion caused by curvature	0%	25%
25%	distortion due to the moisture removal system of the aircraft (defog wiring, gold inlay, etc.)	0%	33%
38%	vision blockage due to interior design	0%	50%
69%	vision blockage due to vertical and horizontal supports	100%	58%
19%	vision blockage due to other add-on equipment/ systems	25%	17%
6%	no problems	0%	8%

Comments: AH-64: "reflections of maps/pubs on dash"
"does not scatter rain well"

9. Which tasks do you perform through the side windscreens in terrain flight?

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
88%	pilotage(NAV)	100%	83%
100%	obstacle avoidance	100%	100%
100%	aircraft avoidance	100%	100%
75%	landing point reference	75%	75%
63%	target acquisition/ detection	75%	58%
88%	ground clearance	75%	92%
100%	visual orientation	100%	100%
56%	target engagement	75%	50%
75%	reconnaissance	100%	66%
0%	other	0%	0%

10. Check any problems that you have experienced with the side windscreens in terrain flight:

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
0%	too small in area	0%	0%
0%	improper placement	0%	0%
50%	glare from interior lights	100%	33%
19%	glare from external lights	25%	17%
19%	distortion caused by curvature	25%	17%
6%	vision blockage due to interior design	0%	8%
44%	vision blockage due to vertical and horizontal supports	75%	33%
19%	vision blockage due to other add-on equipment/ systems	50%	8%
25%	no problems	0%	33%

Comments: AH-64: "can't see rear of aircraft"

11. Which tasks do you accomplish through the overhead windscreens while performing terrain flight?

Combined copilot/gunner (n=16)		AH-1 (n=4)	AH-64 (n=12)
19%	pilotage(NAV)	0%	25%
38%	obstacle avoidance	50%	33%
81%	aircraft clearance	75%	83%
13%	landing point reference	0%	17%
38%	target acquisition/detection	50%	33%
13%	ground clearance	0%	17%
38%	visual orientation	25%	42%
13%	target engagement	0%	17%
13%	reconnaissance	0%	17%
6%	no response	0%	8%
6%	other	0%	8%
	AH-64: "turns"		

12. Identify any problems that you have experienced with the overhead windscreens in terrain flight:

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
6%	too small of an area	0%	8%
0%	improper placement	0%	0%
19%	glare from external lights	25%	17%
31%	glare from interior lights	50%	25%
6%	distortion caused by curvature	0%	8%
6%	vision blockage due to interior design	0%	8%
25%	vision blockage due to vertical and horizontal supports	25%	25%
6%	vision blockage due to other add-on equipment/ systems	0%	8%
50%	no problems	25%	58%

Comments: AH-1: "haze from scratches"

13. Which tasks do you accomplish through the front windscreens while performing above terrain flight?

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
88%	pilotage(NAV)	75%	92%
81%	obstacle avoidance	100%	75%
94%	aircraft avoidance	100%	92%
75%	landing point reference	75%	75%
69%	target acquisition/ detection	75%	66%
63%	ground clearance	50%	66%
100%	visual orientation	100%	100%
63%	target engagement	75%	58%
63%	reconnaissance	75%	58%
0%	other	0%	0%

14. Identify any problems that you have experienced with the front windscreens in above terrain flight:

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
19%	too small of an area	0%	25%
0%	improper placement	0%	0%
56%	glare from interior lights	100%	42%
19%	glare from external lights	25%	17%
19%	distortion caused by curvature	25%	17%
31%	distortion due to the moisture removal system of the aircraft (defog wiring, gold inlay, etc.)	0%	42%
50%	vision blockage due to interior design	100%	33%
81%	vision blockage due to vertical and horizontal supports	100%	75%
19%	vision blockage due to other add-on equipment/systems	25%	17%
19%	no problems	0%	25%

15. Which tasks do you accomplish through the side windscreens while performing above terrain flight?

Combined copilot/gunner (n=16)		**AH-1** (n=4)	**AH-64** (n=12)
88%	pilotage(NAV)	100%	83%
69%	obstacle avoidance	100%	58%
94%	aircraft avoidance	100%	92%
69%	landing point reference	75%	66%
56%	target acquisition/ detection	75%	50%
50%	ground clearance	50%	50%
94%	visual orientation	100%	92%
44%	target engagement	50%	42%
63%	reconnaissance	75%	58%
0%	other	0%	0%
6%	no response	0%	8%

16. Check any problems that you have experienced with the side windscreens in above terrain flight:

Combined copilot/gunner (n=16)		AH-1 (n=4)	AH-64 (n=12)
6%	too small in area	0%	8%
6%	improper placement	0%	8%
50%	glare from interior lights	100%	33%
19%	glare from external lights	25%	17%
25%	distortion caused by curvature	25%	25%
19%	vision blockage due to interior design	0%	25%
56%	vision blockage due to vertical and horizontal supports	75%	50%
19%	vision blockage due to other add-on equipment/ systems	50%	8%
25%	no problems	0%	33%

Comments: AH-64: "I have experienced one incident where the horizontal windscreen support structures (hid) a Cessna 152 that was approaching on collision course from the left front (It) was not detected until it was about 500 meters away"

17. Which tasks do you accomplish through the overhead windscreens while performing above terrain flight?

Combined copilot/gunner (n=16)	**AH-1** (n=4)	**AH-64** (n=12)
25% pilotage(NAV)	0%	33%
44% obstacle avoidance	75%	33%
88% aircraft clearance	75%	92%
19% landing point reference	0%	25%
19% target acquisition/detection	0%	25%
13% ground clearance	0%	17%
38% visual orientation	25%	42%
25% target engagement	25%	25%
19% reconnaissance	0%	25%
6% other	0%	8%

AH-64: "avoidance of other aircraft"

18. Identify any problems that you have experienced with the overhead windscreens in above terrain flight:

Combined copilot/gunner (n=16)		AH-1 (n=4)	AH-64 (n=12)
0%	too small of an area	0%	0%
0%	improper placement	0%	0%
13%	glare from external lights	0%	17%
31%	glare from interior lights	75%	17%
6%	distortion caused by curvature	0%	8%
0%	vision blockage due to interior design	0%	0%
25%	vision blockage due to vertical and horizontal supports	25%	25%
6%	vision blockage due to other add-on equipment/ systems	0%	8%
63%	no problems	25%	75%

Questions 19-24 are not applicable to AH-1 and AH-64 attack aircraft.

25. Rate the overall external viewability through present windows in the aircraft:

Combined copilot/gunner (n=16)	**AH-1** (n=4)	**AH-64** (n=12)
0% very poor	0%	0%
0% poor	0%	0%
50% borderline	75%	42%
44% good	25%	50%
6% very good	0%	8%

If less than good, to what do you attribute this?

AH-1: "internal glare and blocking due to vertical struts"
"frame blocks view"

AH-64: "large supports, poor forward viewing"
"aircraft configuration limits forward visibility"
"structural supports limit visibility"
"support structures"
"supports in front windshield"

Note: Due to rounding errors, totals may not be exactly 100%.

26. Are there any external aircraft components that you would like to periodically visually check during flight that you can not normally see?

Combined copilot/gunner (n=16)	**AH-1** (n=4)	**AH-64** (n=12)
38% yes	75%	25%
50% no	25%	58%
13% no response	0%	17%

If yes, which component(s) do you like to see?

AH-1: "rear"; "armament"; "tail area"
AH-64: "engines"(3); "pylons"

How would you suggest accomplishing this task (mirrors, larger window, chin bubbles, etc.)?

AH-1: "mirrors"(3)
AH-64: "mirrors"(3)

27. Which type of windscreen configuration would you prefer?

Combined copilot/gunner (n=16)		AH-1 (n=4)	AH-64 (n=12)
50%	one with flat windows and window support posts	50%	50%
31%	continuous one piece curved windscreens without posts but with related distortion problems	50%	25%
19%	no response	0%	25%

28. Identify any problems you have experienced due to windscreen material by placing a **G** for glass, **P** for plexiglass, and a **O** for other material(_____).

Combined copilot/gunner (n=16)	**AH-1** (n=4)	**AH-64** (n=12)
POLYCARBONATE		
44% distortion (waviness)	75%	42%
13% chipping	0%	17%
75% haze	100%	66%
19% frequent replacement	25%	17%
81% scratches due to improper cleaning	100%	75%
56% scratches from the environment	75%	50%
25% cracks	25%	25%
38% crazing	50%	33%
0% other	0%	0%
GLASS		
0% distortion (waviness)	0%	0%
6% chipping	0%	8%
19% haze	0%	25%
0% frequent replacement	0%	0%
19% scratches due to improper cleaning	0%	25%
13% scratches from the environment	0%	17%
13% cracks	0%	17%
6% crazing	0%	8%
0% other:	0%	0%
6% no response	0%	8%

29. Has the location of a window ever caused object/image displacement problems (prismatic deviation)?

Combined copilot/gunner (n=16)	**AH-1** (n=4)	**AH-64** (n=12)
25% yes	25%	25%
75% no	75%	75%

If yes, please explain:

AH-1: "curvature of side windows"
AH-64: "oblong view"
"taillights"

30. Is there a visual port(window) placed such that flicker vertigo is a reoccurring problem?

Combined copilot/gunner (n=16)	**AH-1** n=4)	**AH-64** (n=12)
13% yes	50%	0%
88% no	50%	100%

If yes, please explain:

AH-1: "placement of anticollision lights"

31. Are you able to adjust your seat in the aircraft to obtain what you would consider an optimal pilot-eye-position for your aircraft?

Combined copilot/gunner (n=16)	**AH-1** (n=4)	**AH-64** (n=12)
31% yes	50%	25%
69% no	50%	75%

If not, please explain:

AH-1: "Gunner's seat is fixed"
"Front seat (is) not adjustable."
AH-64: "TADS ORT presents an obstacle..."
"instrument panel\glare shield"
"attack aircraft are inherently less visual"
"lose sight of landing area"
"during normal approach I lose sight of landing area"
"forward viewing very poor"

32. From your experience in attack type helicopters with tandem seating, which seating arrangement would you prefer when considering the visual requirements for that mission?

Combined copilot/gunner (n=16)	**AH-1** (n=4)	**AH-64** (n=12)
56% pilot in the aft seat, copilot/gunner in front	25%	66%
44% pilot in the front seat, copilot/gunner in the aft	75%	33%

33. Does the use of helmet-mounted devices (e.g., NVGs, ANVIS) cause any additional conflicts with the external vision in the aircraft?

Combined copilot/gunner (n=16)	**AH-1** (n=4)	**AH-64** (n=12)
56% yes	100%	42%
38% no	0%	50%
6% no response	0%	8%

If yes, please explain:

AH-1: "Glare form canopy can cause problems.(2)"
AH-64: "NVGs hit the ORT"

34. Please comment on any other problems regarding windscreens (no matter how general or specific in nature) not previously addressed:

AH-1: "Scratches and glare are #1 visual problem in AH-1 canopy."
"Develop windscreen covers."
"Replace plexiglass with glass windscreen."
AH-64: "(need) more scratch resistance"
"approaches are harder in tandem seated aircraft"

Appendix F.

Crewman questionnaire data

The format for presenting the questionnaire data consists of stating each question and providing the percentage of respondents selecting each possible choice of response. Where appropriate, data also are presented by aircraft type, where the value reported represents the percentage of respondents for the particular aircraft type selecting each choice of response. For questions where comments were requested, representative comments were selected for inclusion in the following data on the basis of frequency of occurrence or uniqueness.

1. Which tasks do you perform accomplish through the rear ports/door windows/gunner windows while performing hover/taxi?

All aircraft (n=71)		**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
30%	pilotage(NAV)	0%	80%	50%	29%
86%	ground clearance	100%	80%	80%	83%
96%	obstacle avoidance	93%	100%	90%	98%
97%	aircraft clearance	100%	100%	90%	98%
96%	aircraft avoidance	93%	100%	90%	98%
42%	target engagement	7%	40%	30%	57%
92%	landing point clearance	86%	100%	90%	93%
63%	reconnaissance	64%	100%	50%	62%
51%	target acquisition/detection	14%	80%	40%	62%
65%	check aircraft for mechanical and safety problems	93%	20%	40%	67%
0%	none	0%	0%	0%	0%
1%	other	0%	0%	0%	2%
	UH-60: "external load observation"				

2. Check any problems that you have experienced with the rear ports/door windows/gunner windows while performing hover/taxi:

All aircraft (n=71)		**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
34%	too small in area	50%	40%	0%	36%
8%	improper placement	14%	20%	10%	5%
17%	glare from interior lights	14%	60%	10%	14%
14%	glare from external lights	0%	40%	10%	17%
24%	distortion caused by curvature	21%	20%	0%	31%
32%	vision blockage due to interior design	7%	100%	40%	31%
44%	vision blockage due to other add-on equipment/systems	21%	40%	10%	60%
42%	vision blockage due to vertical and horizontal supports	0%	60%	20%	60%
10%	no problems	0%	0%	20%	12%
3%	no response	0%	0%	10%	2%

Comments: CH-47: "NVGs in bubble windows"
"Seat placement does not work."
UH-60: "not enough room between seats and windows"

3. Which tasks do you accomplish through the rear ports/door windows/gunner windows while performing terrain flight?

All aircraft (n=71)		**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
31%	pilotage(NAV)	0%	60%	30%	38%
82%	ground clearance	100%	60%	70%	81%
90%	obstacle avoidance	93%	80%	100%	88%
85%	aircraft clearance	93%	80%	80%	83%
87%	aircraft avoidance	86%	80%	90%	88%
42%	target engagement	7%	40%	40%	55%
76%	landing point clearance	86%	80%	70%	74%
61%	reconnaissance	57%	80%	60%	60%
46%	target acquisition/detection	7%	60%	40%	60%
62%	check aircraft for mechanical and safety problems	86%	20%	40%	64%
6%	none	0%	20%	0%	7%
0%	other	0%	0%	0%	0%

4. Check any problems that you have experienced with the rear ports/door windows/gunner windows in terrain flight:

All aircraft (n=71)		**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
31%	too small in area	43%	40%	20%	29%
13%	improper placement	14%	20%	20%	10%
14%	glare from interior lights	14%	40%	0%	14%
6%	glare from external lights	0%	0%	0%	10%
20%	distortion caused by curvature	7%	40%	0%	26%
30%	vision blockage due to interior design	7%	80%	30%	31%
42%	vision blockage due to other add-on equipment/systems	21%	20%	20%	57%
35%	vision blockage due to vertical and horizontal supports	0%	40%	20%	52%
18%	no problems	14%	0%	40%	17%
4%	no response	0%	20%	10%	2%

Comments: CH-47: "problems with NVGs in bubble windows"(2)
UH-60: "improper cleaning"

5. Which tasks do you accomplish through the rear ports/door windows/gunner windows in above terrain flight?

All aircraft (n=71)		**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
37%	pilotage(NAV)	0%	60%	40%	45%
55%	ground clearance	36%	60%	50%	62%
70%	obstacle avoidance	71%	80%	50%	74%
75%	aircraft clearance	71%	80%	70%	76%
89%	aircraft avoidance	93%	80%	80%	90%
37%	target engagement	7%	20%	30%	50%
54%	landing point clearance	43%	60%	40%	60%
51%	reconnaissance	29%	60%	50%	57%
42%	target acquisition/detection	0%	60%	20%	60%
58%	check aircraft for mechanical and safety problems	79%	20%	30%	62%
7%	none	0%	20%	10%	7%
1%	no response	0%	0%	0%	2%
0%	other	0%	0%	0%	0%

6. Check any problems that you have experienced with the rear ports/door windows/gunner windows in above terrain flight:

All aircraft (n=71)		**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
28%	too small in area	29%	40%	10%	31%
14%	glare from interior lights	14%	40%	0%	14%
4%	improper placement	0%	20%	10%	2%
15%	glare from external lights	14%	0%	0%	17%
20%	distortion caused by curvature	0%	20%	10%	29%
28%	vision blockage due to interior design	14%	60%	30%	29%
34%	vision blockage due to other add-on equipment/systems	14%	20%	0%	50%
41%	vision blockage due to vertical and horizontal supports	0%	40%	20%	60%
31%	no problems	43%	20%	50%	24%
3%	no response	0%	20%	0%	2%

Comments: UH-60: "need new design for gunner's windows"

7. Which tasks do you perform through the front windscreens?

All aircraft (n=71)		**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
32%	pilotage(NAV)	0%	100%	70%	26%
25%	ground clearance	0%	100%	60%	17%
42%	obstacle avoidance	7%	100%	90%	36%
32%	aircraft clearance	0%	100%	70%	26%
49%	aircraft avoidance	7%	100%	80%	50%
17%	target engagement	0%	40%	30%	17%
28%	landing point clearance	7%	100%	60%	19%
17%	reconnaissance	7%	100%	50%	26%
25%	target acquisition/detection	0%	100%	40%	21%
11%	check aircraft for mechanical and safety problems	0%	20%	30%	10%
44%	none	93%	0%	10%	40%
3%	no response	7%	0%	0%	2%
0%	other	0%	0%	0%	0%

8. Check any problems that you have experienced with the front windscreens:

All aircraft (n=71)		**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
4%	too small in area	0%	20%	0%	5%
1%	improper placement	0%	20%	0%	0%
18%	glare from interior lights	0%	40%	10%	24%
4%	glare from external lights	0%	20%	10%	2%
6%	distortion caused by curvature	0%	40%	20%	0%
20%	vision blockage due to interior design	0%	100%	10%	19%
10%	vision blockage due to other add-on equipment/systems	0%	60%	20%	5%
20%	vision blockage due to vertical and horizontal supports	0%	80%	10%	21%
46%	no problems	79%	0%	40%	43%
14%	no response	21%	0%	10%	14%

9. Which tasks do you perform through the bubble only windows in the fuselage? **FOR CH-47 AIRCRAFT ONLY.**

	CH-47 (n=14)
pilotage(NAV)	0%
ground clearance	86%
obstacle avoidance	93%
aircraft clearance	86%
aircraft avoidance	93%
target engagement	0%
landing point clearance	86%
reconnaissance	71%
target acquisition/detection	14%
check aircraft for mechanical and safety problems	86%
none	0%
no response	0%
other	7%

10. Check any problems that you have experienced with the bubble windows in the fuselage: **FOR CH-47 AIRCRAFT ONLY.**

	CH-47 (n=14)
too small in area	43%
improper placement	0%
glare from interior lights	14%
glare from external lights	7%
distortion caused by curvature	21%
vision blockage due to interior design	7%
vision blockage due to other add-on equipment/systems	7%
vision blockage due to vertical and horizontal supports	0%
no problems	0%
no response	0%

Comments: CH-47: "use of NVGs in bubble windows"(3)
"need bubble in forward area for cold weather ops"

11. Rate the overall external viewability through present windows in the aircraft:

All aircraft (n=71)	**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
6% very poor	7%	20%	0%	5%
4% poor	7%	0%	0%	5%
34% borderline	14%	40%	0%	48%
49% good	71%	40%	70%	38%
3% very good	0%	0%	20%	0%
4% no response	0%	0%	10%	5%

If less than good, to what do you attribute this?

CH-47: "windows too small"
"Seat placement does not allow for proper monitoring."
OH-58C: "too many add-ons"
UH-60: "dash too high"
"center beam"

12. Are there any external aircraft components that you would like to periodically visually check during flight that you can not normally see?

All aircraft (n=71)	**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
15% yes	0%	40%	0%	21%
75% no	100%	60%	90%	64%
10% no response	0%	0%	10%	14%

If yes, which component(s) do you like to see?

OH-58C: "skids"(2)
UH-60: "tail and landing gear"
"sling loads"
"landing light"

How would you suggest accomplishing this task:

OH-58C: "mirrors"; "larger windows"; "new windows"
UH-60: "mirrors(2)"; "larger window";"new windows"; "TV camera"; "larger seat restraints"

13. Identify any problems you have experienced due to windscreen material by placing a **G** for glass, **P** for plexiglass, and a **O** for other material(_____).

All aircraft (n=71)	**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
POLYCARBONATE				
24% distortion (waviness)	14%	40%	10%	29%
8% chipping	14%	20%	0%	7%
51% haze	43%	60%	0%	64%
10% frequent replacement	14%	0%	10%	10%
48% scratches due to improper cleaning	43%	60%	40%	50%
61% scratches from the environment	57%	80%	30%	67%
11% cracks	21%	20%	0%	10%
35% crazing	57%	0%	30%	33%
1% other	0%	0%	0%	2%
UH-60: "pitting (2)"				
GLASS **See note.**				
0% distortion (waviness)	0%	0%	0%	0%
7% chipping	7%	0%	0%	10%
0% haze	0%	0%	0%	0%
8% frequent replacement	0%	0%	0%	14%
3% scratches due to improper cleaning	7%	0%	0%	2%
25% scratches from the environment	7%	0%	0%	40%
23% cracks	0%	0%	0%	38%
4% crazing	0%	0%	0%	7%
0% other	0%	0%	0%	0%
13% no response	14%	0%	40%	7%

Note: The OH-58C are fielded with acrylic windscreens only.

14. Has the location of a window ever caused object/image displacement problems (prismatic deviation)?

All aircraft (n=71)	**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
10% yes	14%	20%	0%	10%
82% no	71%	80%	90%	83%
8% no response	14%	0%	10%	7%

If yes, please explain:

OH-58C: "Minor scratches can cause large objects to be hidden from view."
UH-60: "green house windows during formation flights"
"cockpit door windows"

15. Does the use of helmet-mounted devices (e.g., NVGs, ANVIS) cause any additional conflicts with the external vision in the aircraft?

All aircraft (n=71)	**CH-47** (n=14)	**OH-58C** (n=5)	**UH-1** (n=10)	**UH-60** (n=42)
48% yes	86%	80%	50%	33%
41% no	14%	20%	40%	52%
10% no response	0%	0%	10%	14%

If yes, please explain:

CH-47: "(use of) NVG in bubble windows"(10)
"haze"
OH-58C: "not enough room for head movement"
"Stinger mod gets in the way."
UH-1: "(with) cargo doors closed, NVGs can make contact with window"
"with command console installed. KY-58s have red lights. You can't see out of windows because of glare - only with doors closed"
UH-60: "during NVG use, size of windows restrict vision"
"necessary to lean out the window with NVGs"
"interior light reflections"
"limited view during refuel"
"must leave window open to see"
"restricts field of view while scanning"

16. Please comment on any other problems regarding windscreens (no matter how general or specific in nature) not previously addressed:

CH-47: "Make cabin windows larger."
OH-58C: "windscreens not durable enough"
UH-60: "larger cargo hook section for better visibility"
"difficulty opening and closing cargo doors at cruising speeds"

Appendix G.

Accident synopses.

Aircraft type	Accident class	Relevant findings
AH-1F	C	(1) "The weather was rainy causing droplets of rain to form on the copilot's (back) windscreen. The copilot was having some visibility problems...visibility was severely reduced as a result of a combination of dust and drizzle on the windscreen." (Present and contributing)
AH-1G	C	(1) "The crew chief's helmet was marked with orange and white reflective tape which reflected on the front canopies hampering the pilot's visibility." (Factor which contributed or is suspected to have contributed) (2) "The windshield was checked and distorted in various places possibly hampering visibility." (Factor which contributed or is suspected to have contributed)
AH-64A	C	(1) "...factor was the obstruction of field-of-view (FOV) by the inadequate design of the canopy frame members in the cockpit...That is, outside areas subtended by the frame members in conjunction with the left to right rolling motion of the NOE maneuvers contributed to obstruction of the pilot's FOV of the trees and cactus." (Present and contributing)
OH-58A	C	(1) "Raindrops were present on windscreen possibly reducing forward visibility which may have contributed to misjudging clearance." (Present and contributing)
OH-58A	C	(1) "Pilot's vision was blocked by glare when he turned into the sun during takeoff." (Definite cause factor) (2) "Windshield was moderately crazed." (Suspect cause factor)
OH-58A	B	(1) "The pilot's windscreen was written up as 'crazed'...The windshield had not been replaced." (Present but not contributing) (2) "The CP opened his door in-flight to gain visual reference with the ground." (Present but not contributing)
OH-58A	C	(1) "Sudden reduction in visibility due to glare on crazed windshield caused pilot not to see tree until it was too late to avoid." (Present and contributing)

Appendix G (Continued).

Accident synopses.

Aircraft type	Accident class	Relevant findings
OH-58A	C	(1) "Pilot and copilot windshields...were declared distorted by the crew chief...was selected for unaided night/NVG training by...the maintenance officer for the troop. The distorted windshields caused visual restrictions during flight." (Present and contributing)
OH-58A	C	(1) "Combination of windscreen fog, rain, glare restricted the pilots visibility outside the aircraft." (Present and contributing) (2) "Aircraft defog system was not capable of keeping the windscreen clear." (Present and contributing) (3) "Pilots attention was distracted by poor visibility and weather conditions to a point that he did not realize he was descending." (Present and contributing)
OH-58A	C	(1) "The sun's glare on the windshield did not allow the pilot to observe the bird in time to avoid hitting the bird." (Present and contributing)
OH-58C	C	(1) "The PI focused his attention through the lower right corner of the windscreen due to reduced visibility from moisture accumulation on the windscreen. By focusing his attention in one area, the PI failed to scan the other ground references available to him through the cockpit door openings." (Present and contributing: human error-training failure)
UH-1M	C	(1) "The reduced visibility caused by a glare on the instructor pilot's glass windscreen reducing the instructor pilot's acquisition and avoidance time." (Present and contributing) (2) "Dirty and pitted windshield caused by burning rocket propellant aggravated the glare on the instructor pilot's glass windshield." (Suspected contributing factor)

Accident synopses.

Aircraft type	Accident class	Relevant findings
UH-60A	A	(1) "The crews of the two converging aircraft failed to see and avoid each other because of visual limitations associated with the AN/PVS-5 NVGs, coupled with the field of view restrictions of UH-60A aircraft." (Present and contributing) (2) "The crew chief's and gunner's windows do not provide adequate field of view for flying NVGs due to fore, aft, and center window obstructions." (Present but not contributing)
UH-60A	A	(1) "Numerous blind spots in the UH-60 resulted in inadequate field of vision allowing other aircraft to approach undetected." (Present and contributing) (2) "Center console radios are not NVG compatible and caused both pilots to focus their attention inside the cockpit instead of clearing their aircraft of traffic." (Present and contributing) (3) "The AN/PVS-5 restrict through the tube visibility to 40 degrees even with the flip-up mounts. Crew members on both aircraft had increased peripheral blind spots from the cutaway mounts which allowed the other aircraft to approach undetected." (Present and contributing)
UH-60A	C	(1) "The 0% illumination below the tree line just after EENT and the water spray on the windshield contributed to the loss of visual references." (Present and contributing)

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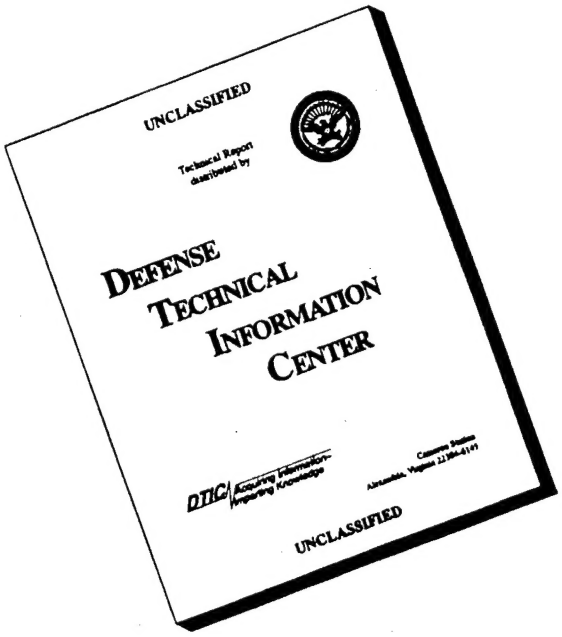

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